PROSPECTING SITE
TECHNICAL SUMMARY
FOR 1987/88
RENEWABLE ENERGY BRANCH

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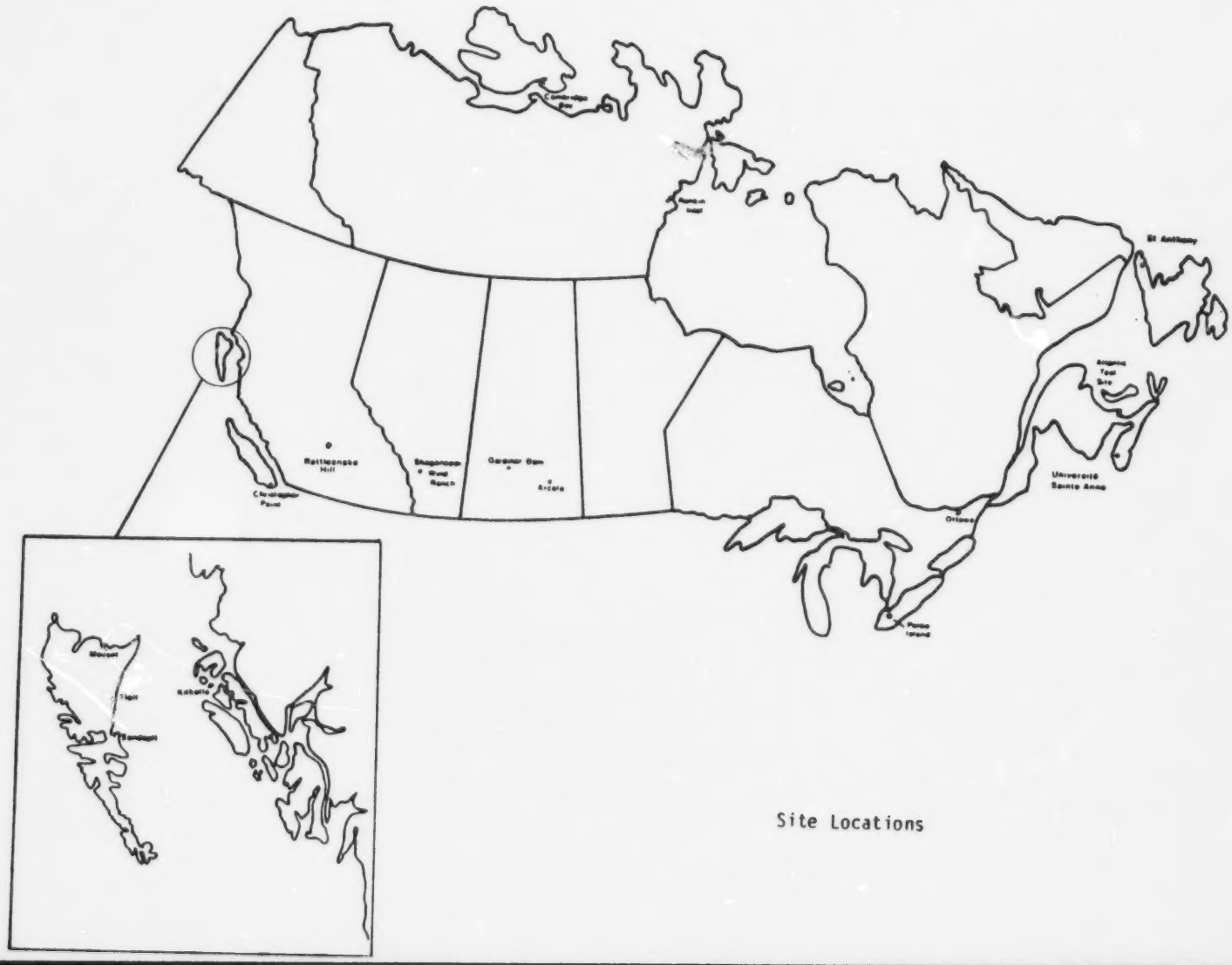


Site Locations

NOMENCLATURE

Variable Name	Description
P(>)	Probability of wind speed exceeding a given windspeed
V	Windspeed (m/s)
A	Weibull scale parameter
K	Weibull shape parameter
Z(V)	Instantaneous rate function
p(V)	Probability density function
R(V)	Reliability function
P(V)	Cumulative distribution function
K_a	Calculated K-value based on full year's data
K_m	Calculated K-value based on individual monthly data
K_{av}	Average of all monthly K_m-values
A_a	Calculated A value based on full year's data
A_m	Calculated A value based on individual monthly data
V_a	Average windspeed based on full year's data (m/s)

NOMENCLATURE (cont'd)

Variable Name	Description
V_m	Calculated average windspeed based on individual monthly data (m/s)
V_{av}	Average of all monthly V_m values (m/s)
p	Standard air density (kg/m^3)
f_{comp}	Air density compensation factor

NOMENCLATURE (cont'd)

Terms used in this report are described below:

Approx. Month of Record	Grouping of data by exact calendar months may be approximate in some cases because of actual dates of data recording.
Total Time in Period	Total number of hours in measurement period (calculated from the continuously running Wind Histogram Recorder data).
Average Wind Speed	Calculated from the continuously running Wind Histogram Recorder data.
Available Wind Energy (Betz Limit)	59.3% of the total energy in the freestream wind which passed through the cross-sectional area of a DAF-INDAL 17 m by 11 m VAWT, i.e. 124.7 m^2. (Calculated from the continuously running Wind Histogram Recorder data).

1. INTRODUCTION

The recent interest in developing viable renewable energy sources has led to major research in the area of wind as an alternate source of energy.

The existence of good windy areas, the application of modern technology and analysis techniques to wind energy conversion systems (WECS) has indicated there is a relatively good potential for the existence of WECS in Canada.

The WECS are generally classified as vertical axis or horizontal axis turbines depending upon the rotation of the rotor axis. Until 1986 the dominant wind turbine under study by the National Research Council of Canada, Energy Mines and Resources and T E S Limited was the vertical axis wind turbine (VAWT) first patented by George Darrieus in 1927. The Darrieus rotor is a vertical axis, lift type wind machine having generally two rotor blades with an airfoil cross section. Some advantages of this style of turbine include the fact that it is able to operate independently of wind direction, thus not requiring a complex wind directional guidance system, and since the turbine's axis is vertical, the motor/generator and hydraulic equipment may be situated close to ground level, facilitating maintenance.

In April 1981 T E S Limited was contracted by the National Research Council of Canada to analyze data on wind speed distribution and VAWT performance from numerous wind prospecting and generating sites across Canada. It is hoped that over a period of several years of continued analysis that major conclusions can be formulated regarding the technical viability of installing VAWTs in certain areas of Canada to augment Canada's future electrical generating capability.

In 1986 with the reduction to zero of all energy research and development performed by the NRC Energy Division, Energy Mines and Resources Canada contracted T E S Limited to continue the analysis and reporting of data from the remaining wind prospecting and generating sites.

As of March 1, 1988 the remaining prospecting sites (namely, Universite Ste. Anne, Rattlesnake Hill, Rankin Inlet) were removed from the study and the monthly reporting/data analysis.

The instrumentation used for collecting wind regime data varied somewhat among the sites, but in general consisted of an anemometer mounted on a 20 m tower, and an electronic histogram recorder which samples wind speed every 2 seconds and stores the resulting data as counts in bins representing various wind speed ranges. A typical histogram format consists of 64 bins of 0.5 m/sec width covering the wind speed range of 0 to 31 m/s.

The histogram recorders were read by local personnel, typically once per month, and the data were recorded on data sheets which were then forwarded to T E S Limited for analysis on a regular monthly schedule.

The wind regime data received were analysed to characterize the wind parameters for each site, with particular attention being paid to:

1. Wind speed characteristics
   - average wind speed
   - wind speed distribution
   - wind speed probability distribution
   - Weibull distribution constants K and A (a measure of the wind speed distribution curve shape)

2. Available wind energy and potential turbine output based on a nominal 50 kW VAWT
   - Betz Limit (a measure of the energy contained in the wind)

This report summarizes the data obtained from the three active prospecting sites for the calendar year 1987 and includes summaries for twenty eight sites dating back to site start-up.

Refer to the report entitled "Vertical Axis Wind Turbine Technical Summary for 1987" for data (both actual and estimated) from the "generating" sites mentioned in this introduction.

2. PROSPECTING SITES

During 1987, there were three active prospecting sites in operation. The term "prospecting" describes sites equipped with a basic wind histogram data recorder. The majority of these sites produced enough data to calculate reasonable annual wind characterization parameters.

The yearly summaries include estimated energy (calculated from wind speed distribution data), compared to the available wind energy (Betz Limit).

Table 1 lists the prospecting site names and the status of each site in this report. Data for January, February, 1988 was included in this report for the three active sites.

Table 1

Prospecting Sites Monitored Since Start-Up

Site Name	Report Status
Arcola	Summary for 1984
Atlantic Test Site	Summary for 1982-83-84-85
Bamfield	Summary for 1982-83
Cambridge Bay	Summary for 1984-85
Christopher Point (Lower)	Summary for 1981-82-83-84
Christopher Point (Upper)	Summary for 1981-82-83-84
Destruction Bay	Summary for 1982
Fort Severn	Summary for 1982
French Lakes	Summary for 1983
Gardiner Dam	Summary for 1984-85
Kitkatla	Summary for 1984
Masset (Upper)	Summary for 1982-83-84-85
Masset (Lower)	Summary for 1982-84-85
NRC Ottawa	Summary for 1981-82-83-84
Pelee Island	Summary for 1980-81-84
Rankin Inlet	Summary for 1984-85-86-87
Rattlesnake Hill	Summary for 1986-87
Sandspit (Beban)	Summary for 1982-83-84
Sandspit (Lower)	Summary for 1983-84-85
Sandspit (Upper)	Summary for 1983-84
Shaganappi Wind Ranch	Summary for 1984
St. Anthony	Summary for 1986
Surge Lake	Summary for 1982-83
Tlell	Summary for 1983-84
University Ste. Anne	Summary for 1986-87
Walters Cove	Summary for 1983
West Dalhousie	Summary for 1982-83
Winisk	Summary for 1980-81-82

3. AVERAGE WIND SPEED

As Atmospheric Environment Service (AES) data is tabulated on a monthly/yearly basis, the data from each prospecting site was reduced on a monthly and yearly basis to permit comparison with the closest AES station. The following AES stations were used:

PROSPECTING SITE	CLOSEST AES STATION
Arcola	Regina, Saskatchewan
Atlantic Test Site	Tignish, P.E.I.
Bamfield	Tofino, B.C.
Cambridge Bay	Cambridge Bay, N.W.T.
Christopher Point	Victoria, B.C.
Destruction Bay	Burwash, Yukon
French Lakes	Sydney, N.S.
Gardiner Dam	Outlook, Saskatchewan
Kitkatla	Sandspit, B.C.
Masset	Sandspit, B.C.
NRC Ottawa	NRC Ottawa, Ontario
Pelee Island	Pelee Island, Ontario
Rankin Inlet	Whale Cove, N.W.T.
Rattlesnake Hill	Rattlesnake Hill, B.C.
Sandspit	Sandspit, B.C.
Shaganappi Wind Ranch	Calgary, Alberta
St. Anthony	St. Anthony, Newfoundland
Surge Lake	Sydney, N.S.
Tlell	Sandspit, B.C.
University Ste. Anne	Weymouth, N.S.
Walters Cove	Spring Island, B.C.
West Dalhousie	Anapolis Royal, N.S.
Winisk, Fort Severn	Winisk, Ontario

4. WIND SPEED DISTRIBUTION

The analysis of histogram data must be comparable from site to site in order to maximize its usefulness. Since the bin boundary definitions and associated bin widths varied in some cases from one histogram recorder to the next, site data were standardized to a common scalar quantity. To standardize the histogram recorder data, the bin count was multiplied by the sampling period and divided by the bin width. This conversion yields a scalar quantity representing the duration of the wind speed in the speed range of a particular bin.

The data representing wind speed distribution was obtained for each site by electronic histogram recorders. Due to the use of different types of anemometer cups (steel or plastic), the bin boundaries varied between sites depending on which type of cups were used. During 1987, all sites used stainless steel cups. A modified grouped frequency distribution (Histogram) was used to facilitate comparison of data between sites. With this type of grouped density distribution, the ordinate no longer represents frequency but a ratio of frequency to the bin width. Thus, by plotting the ordinate as the ratio of time (minutes) spent in a given bin to that bin's width, the resulting histogram will be such that the area of each rectangle is proportional to the class frequency and represents the duration (in minutes) for which the wind speed is within the bounds of the bin.

5. WIND SPEED PROBABILITY

Various plots of wind speed probability can be used to indicate the skew and dispersion of the wind speed histogram. This information is typically used to evaluate or predict turbine performance. With this in mind, wind speed probability was evaluated over the predicted turbine operating wind speed range between the turbine cutin speed (typically 6 m/s) and turbine cutout wind speed (typically 15 m/s).

An analytic probability distribution that has been shown empirically to fit well with a wide range of measured wind speed distributions is the Weibull distribution. This distribution may be expressed in the form

$$P(>V) = e^{-\left[\Gamma(1+\frac{1}{K})\frac{V}{V_{avg}}\right]^K}$$

where $P(V)$ is the probability (or fraction of the total time) that the wind speed will be greater than any specified value V,

$\Gamma(\ )$ is the gamma function

V_{avg} is the average wind speed, assumed to be at the centre height of the rotor

and K is the Weibull exponent parameter.

The gamma function $\Gamma(\ )$ is normally computed from a sufficient number of terms of an infinite series, but the following curve fit for $\Gamma(1+\frac{1}{K})$ gives values accurate to within one-tenth of one percent over the range K = 1.4 to 4.5 which is likely to cover the range of interest in wind energy applications:

$$\Gamma(1+\frac{1}{K}) = 0.8525 + 0.0135K + e^{-(2+3(K-1))}$$

When K = 2 the gamma function reduces to and the Weibull distribution reverts to the special case known as the Rayleigh distribution:

$$P(>V) = e^{-\frac{\pi}{4}\left[\frac{V}{V_{avg}}\right]^2}$$

Also by further simplification and reduction the probability distribution P(>V) can be written as

$$P(>V) = e^{-AV^K}$$

where A is the Weibull scale parameter which can be determined empirically as shown below and V,K are as previously defined.

Since $P(>V) = e^{-AV^K}$

then $\ln(-\ln(P(>V))) = \ln(A) + K \ln(V)$

If the windspeed distribution truly follows the Weibull distribution then, a graph of

$$\ln(-\ln(P(>V))) \text{ versus } \ln(V)$$

should produce a straight line with slope K and intercept ln(A).

Wind histogram data from sites are reduced so as to yield probability [P(>V)] values for each of the 64 bins of the histogram. Each bin, representing a small range of wind speeds, about a mid-bin velocity value (V).

These data pairs were plotted with the Y axis representing ln(-ln(P(>V))) and the X axis ln(V). A least squares first order fit was applied to determine the slope and intercept. As previouslv mentioned, the slope represents the Weibull parameter K and the intercept ln(A).

6.0 WEIBULL PARAMETERS

If a given frequency distribution can be represented by a Weibull distribution, then the Weibull parameters A and K are sufficient to describe that distribution.

The Weibull parameters are readily related to the instantaneous rate function where K is known as the shape parameter and A as the scale parameter.

The instantaneous rate function Z(V) may be written as

$$Z(V) = AKV^{(K-1)}$$

; V = windspeed
; A = Weibull scale parameter
; K = Weibull shape parameter

or $$Z(V) = \frac{p(V)}{R(V)} = \frac{\text{Probability Density Function}}{\text{Reliability Function}}$$

where $$p(V) = \frac{d\,P(V)}{dV}$$; P(V) = Cumulative distribution function

and $$R(V) = 1 - P(V)$$

where the cumulative distribution function P(V) is written as

$$P(V) = 1 - e^{-AV^K}$$

then $$R(V) = e^{-AV^K}$$

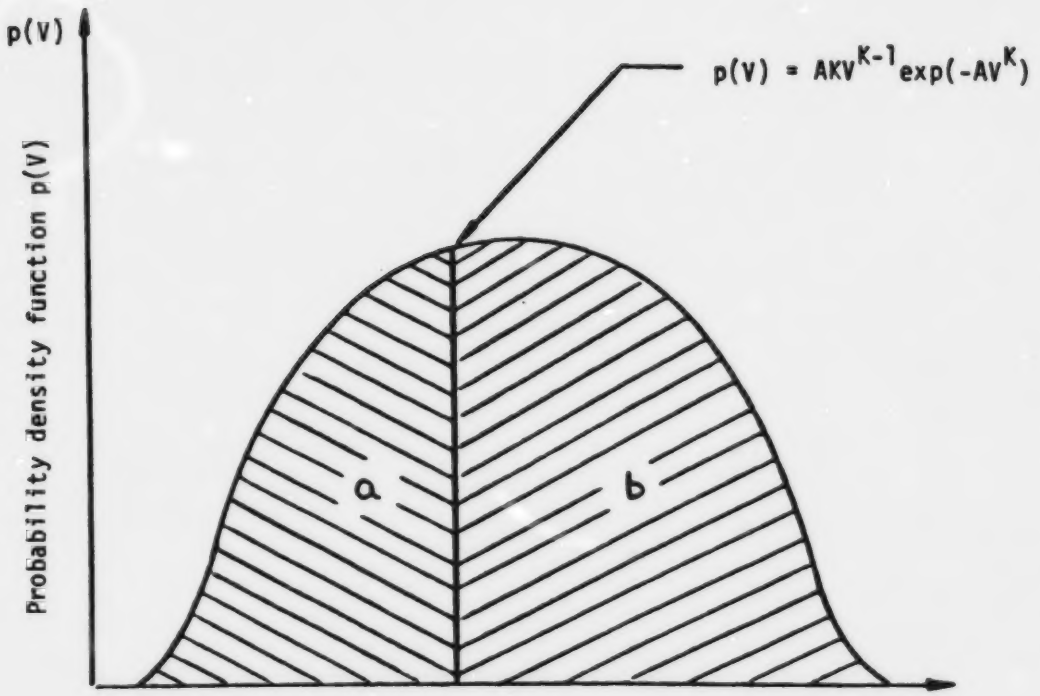
and $$p(V) = AKV^{K-1}\, e^{-AV^K}$$

$p(V) = AKV^{K-1} \exp(-AV^K)$ = probability density function

$P(V)$ = cumulative distribution function

$R(V)$ = reliability function

$Z(V)$ = instantaneous rate function



$a + b = 1$

$p(V) = AKV^{K-1}\exp(-AV^K)$

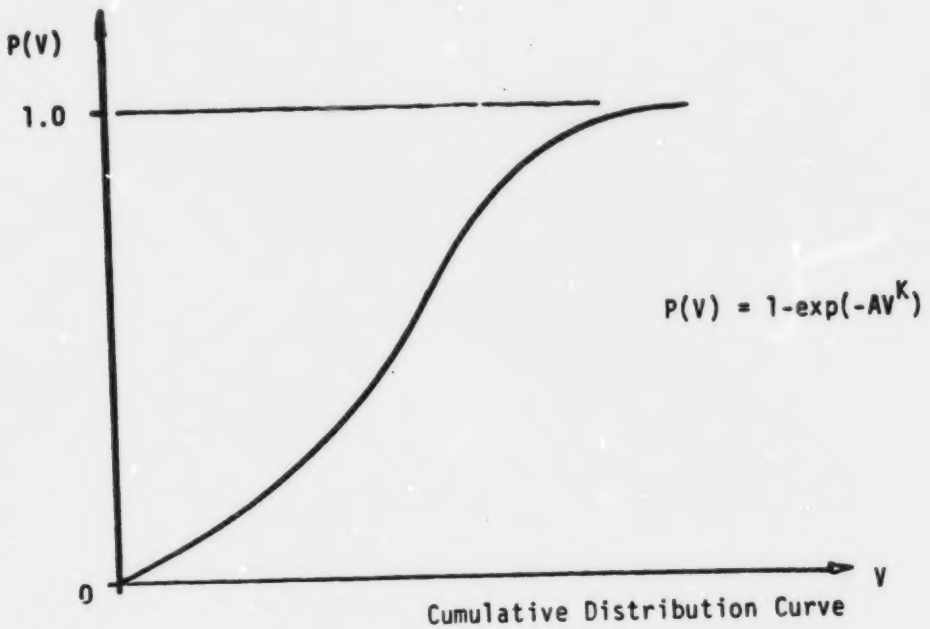
$P(V) = a = \int_0^V p(V)\, dV = 1 - \exp(AV^K)$

$R(V) = 1 - P(V) = b = \exp(-AV^K)$

$Z(V) = \frac{p(V)}{R(V)} = \frac{P(V)}{b} = AKV^{K-1}$

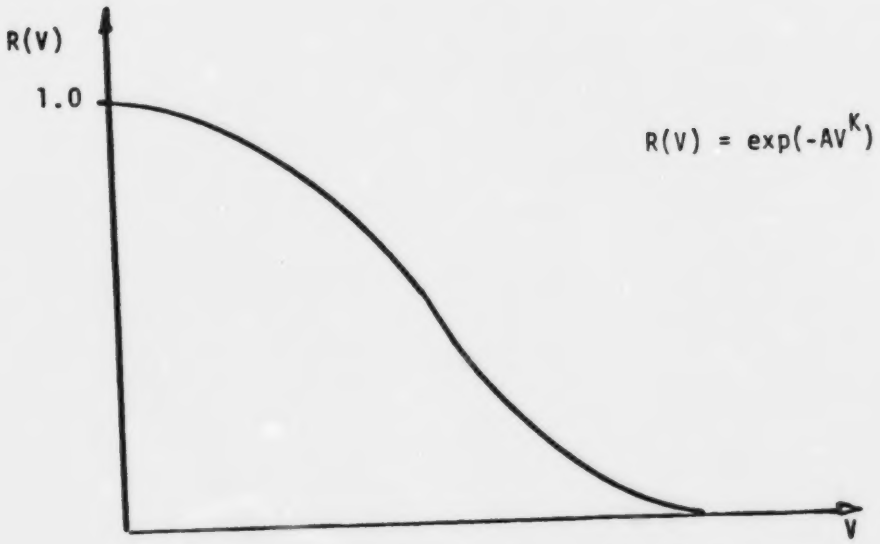
Weibull Distribution Curve

Figure 1



Cumulative Distribution Curve

Figure 2



Reliability Function

Figure 3

6.1 SHAPE PARAMETER

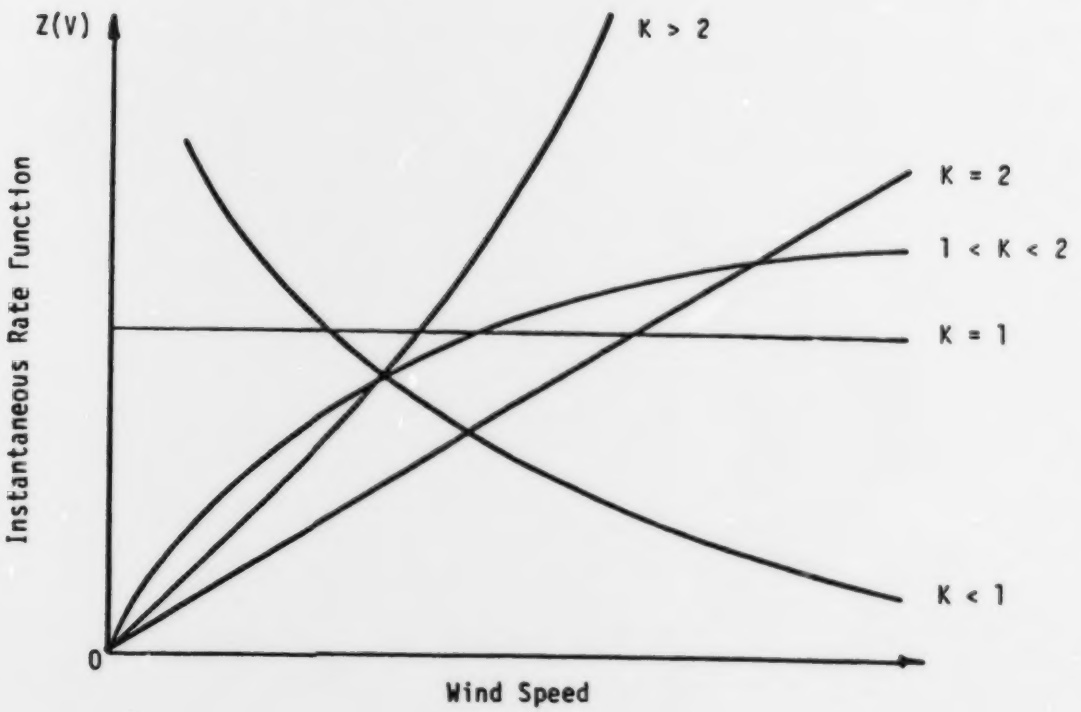
The shape of the instantaneous rate function Z(V) is dependent on K and is related to K by the equation

$$Z(V) = AKV^{(K-1)}$$

Figure 4 below illustrates the effect that the Weibull shape parameter (K) has on the instantaneous rate function Z(V).

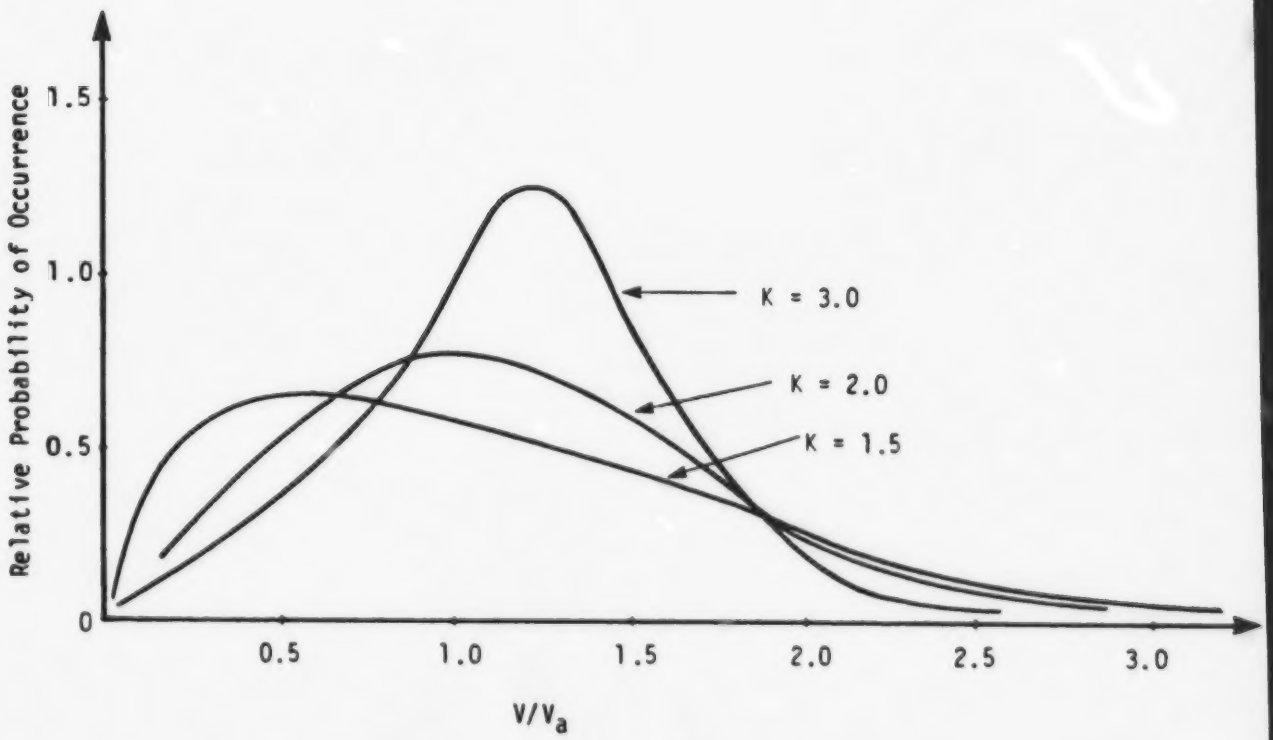
for:

$K > 1$	rate decreases with decreasing gradient
$K = 1$	rate is constant
$1 < K < 2$	rate increases with a decreasing gradient
$K = 2$	rate increases linearly
$K > 2$	rate increases at an increasing gradient



Shape Parameter
Figure 4

Typically, the shape parameter K is a measure of the peakiness of the Weibull distribution around the average wind speed value. High values of K represent relatively steady wind conditions where the most frequent wind speeds are clustered in a narrower range around the average value. Lower values of K represent a more spread out wind speed distribution and usually occurs in regions where average wind speeds are low to moderate. At low values of K the peak of the probability curve is skewed to the left indicating that the most probable wind speed is less than the average speed. Figure 5 illustrates typical distributions for K = 1.5, 2 and 3.



Relative Probability of Wind Speed Weibull Distribution for K = 1.5, 2 and 3

Figure 5

7. BETZ LIMIT

Comparisons of wind turbine efficiency are often made on the basis of aerodynamic efficiency, which is the ratio of shaft power output to the Kinetic energy flow of the wind through the rotor area. This ratio has a theroetical limit of about 59 percent and is generally known as the Betz limit. Practical wind turbines have maximum efficiencies of typically 40 percent, which is about 70 percent of the Betz limit. As an estimate of the upper limit of power attainable from a wind turbine, the Betz limit can be useful in establishing turbine performance.

The Betz limit is converted into terms of energy when multiplied by operational time. In this report, the Betz limit is referred to in terms of energy with units of kWh. This value represents the maximum energy which an ideal wind turbine with no losses can extract from the wind.

A comparison of the Betz limit with actual energy generated or with theoretical energy generation calculations will yield a measure of turbine efficiency.

Note that available wind energy due to the Betz limit is temperature dependent and consequently any calculation of this available energy must assume a given temperature. It should be noted therefore, that this temperature may not match the fluctuating temperature of actual operating conditions. In this report, the temperatures used for the available energy due the Betz limit calculations were monthly/yearly averages obtained from AES data.

8. DISCUSSION

The following paragraphs discuss major areas of interest concerning wind energy data analysis performed by T E S Limited.

8.1 Annual Average Wind Speeds

Two different methods of calculating the annual average wind speeds were used in this report.

V_{av} The average of the monthly-average wind speeds was determined.

$$V_{av} = \frac{\sum_{s_m}^{e_m} V_m}{n} \text{ m/sec}$$

where s_m = startup month of recording period
e_m = end month of recording period
n = recording period in months

The accuracy of this measurement depends on the accuracy of the monthly wind speed histogram. The reader should be aware that corrections were made to the monthly wind histogram in cases where the histogram data were obviously in error due to a histogram malfunction or operator reading error. Any such corrections were identified by footnotes on the respective data sheets.

V_a The annual average wind speed was determined from the annual wind speed histogram. Corrections made to the monthly histogram data were carried forward through to the yearly histogram. As can be seen from Table 3 the difference in the results of the two methods of calculation is not great.

8.2 Annual K-Value

The annual calculated K-value (K_a) should not be confused with the average of the monthly K_m values (K_{av}). Each was calculated differently and describes different characteristics of the wind speed profile data.

K_{av} The annual average K_{av} value is the average of the K_m values which was determined from the monthly histograms.

$$K_{av} = \frac{\sum_{s_m}^{e_m} K_m}{n}$$

where s_m = startup month of recording period
e_m = end month of recording period
n = recording period in months

This annual average with its standard deviation may be used to describe the seasonal fluctuation in the wind speed distribution.

K_a The annual calculated K_a value is based on the annual histogram (sum of the monthly histograms) and thus should be used to describe the annual wind speed distribution and the annual wind energy.

8.3 Sample Size of the Data

Any effort to predict or evaluate site performance based on the information presented must be tempered with the knowledge that this report, in many cases, describes only one cycle of the seasonal variation of the winds at each site. This sample size may not be large enough to accurately show long term trends.

8.4 The Effects of Different Time Periods for Each Monthly Report

Histogram recorders were not read every day. (In most cases the recorders were read once a week or less.) Thus, data reduction could not be performed from the beginning to the end of every month. Therefore, the time period of each monthly data reduction varied from site to site and month to month. No direct comparison between sites' performance can be made unless the time period is taken into account.

The magnitude of all the energy measurements and calculations is dependent on the time period over which the measurements or calculations were made as well as the shape of the wind speed profile. An increase in one of these parameters may be the result of higher winds or a longer measurement period.

It may be interesting to note the effect caused by the differing wind speed profiles. This effect may be obtained by dividing each parameter of interest by its associated time period.

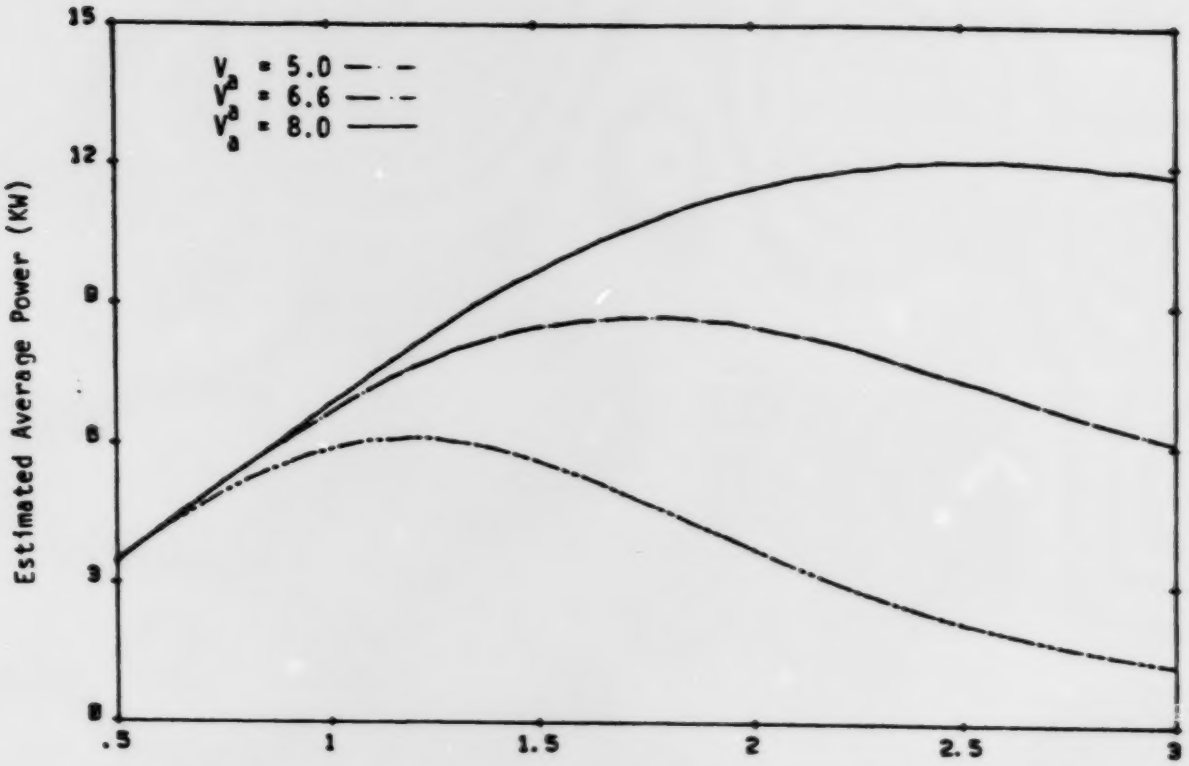
8.5 The Effects of Average Wind Speed and Weibull Parameter K on Theoretical Energy

Since lower values of the Weibull shape parameter K, indicate that for a larger proportion of time the wind speed was within the upper regions of the turbine wind speed energy profile, then, for a given mean wind speed and low K-value, it could be suggested that more energy could be produced from the wind.

Also, for a given value of K, higher average wind speeds would indicate larger quantities of energy in the wind.

It appears that for values of K above approximately 1.6 there is little time where the wind speed is in the vicinity of the cutout wind speed. Thus, calculations using various values of cutout wind speed will yield similar results for the theoretical energy. For wind speed Weibull distributions, where the K-value is below 1.6, there is a significant time when the wind speed is at or above the cutout wind speed. For these distributions, significant energy could be derived with an increase in turbine cutout speed. This may be evaluated by comparing graphs of the K value with graphs of the turbine theoretical energy.

Figure 6 shows the effects of average wind speed and Weibull parameter K on estimated power output. The instantaneous power curve for a 50 kW VAWT was used with generation limits set to cutin at a windspeed of 6.6 m/s and cutout at a windspeed of 15.65 m/s. The estimated output power is the average power that would be expected from a VAWT in one hour of operation if the wind followed a Weibull distribution.



Effect of Average Wind Speed and K-value
on Estimated Average Power from a 50 kW VAWT

Figure 6

8.6 Equipment Failures, Errors and Error Correction

The reader should be familar with previous monthly site reports prepared by T E S Limited during this program.

These reports discuss equipment failure, operator error and the methods of correction that were applied to these errors. Any analysis of the results reported here should include a familiarization with the equipment and instrumentation at each site as well as errors and corrections in the data.

Errors in the data recorded are not noted in this report except in cases where the data were seriously compromised or where significant amounts of data were missing.

During the period covered by this report, a number of sites were shut down due either to equipment failure, as in the case of a failed anemometer, or for periodic maintenance. The lack of data during this down time meant that various performance figures could not be calculated for the site.

Also, some wind prospecting sites supplied single data sheets representing data collected over a time period as long as 3 months. with no previous information concerning these sites, it was decided not to split the data into arbitrary monthly segments as this could misrepresent the actual wind distribution at the site.

8.7 The Effects of Temperature

The density of the working fluid of turbo machinery must be included in any calculations of power or energy. Two such calculations are reported here, the Betz limit and the estimated energy. In the case of Vertical Axis Wind Turbines, the working fluid is air, where the density is dependent on pressure, temperature and humidity.

For the Betz limit calculation, temperature compensation was applied. For each monthly report, the average monthly temperature was used based on data from the closest AES station. Pressure was assumed constant at 101.325 kPa (14.7 psi). Humidity was ignored.

Any other treatment of the air density would have been very difficult because of a lack of local data.

Turbine theoretical energy calculations summarized in reports previous to the 1983 annual report did not compensate for this effect of varying local air density.

In deriving the air density compensation factors for each site, it was assumed that the DAF-Indal turbine power output curve was calibrated for standard conditions, i.e. at sea level.

$$\rho = 1.225 \text{ kg/m}^3$$
$$P = 101.3 \text{ kPa}$$
$$T = 288.15^{\circ}\text{K}$$

where ρ = air density
P = atmospheric pressure
T = ambient temperature

Since turbine output power is directly related to air density the calculated output energy can be adjusted to compensate for air density changes by the following factor:

Compensated Energy Output = Calculated Energy Output x f_{comp}

where $f_{comp} = \frac{P_{site}}{P} \times \frac{T}{T_{site}}$

P_{site} is the site standard atmospheric air pressure as determined by altitude

and T_{site} is the site temperature as averaged over the data collection period. AES Temperature normals at locations closest to the wind test site are used to obtain this temperature value.

Table 2 listing the US Standard Atmosphere is used to approximate the standard air pressure at the altitude of the wind test sites in this test program.

Table 2

U.S. STANDARD ATMOSPHERE—METRIC UNITS

Altitude		Temperature, t		Pressure, P		Density, ρ, kg/m^3	Gravity, g, m/s^2	Molecular weight, M	Velocity of sound, V_s, m/s	Viscosity, μ, $kg/m \cdot s \times 10^5$	Conductivity, k, $kcal \times 10^5$ $m \cdot s \cdot K$
Geometric, Z, m	Geopotential, H, m	deg C	K	mbar	mm Hg						
0	0	15.00	288.15	1 013.3	760.	1.225	980.7	28.96	340.3	1.789	.605 3
200	200	13.70	286.85	989.5	742.	1.202	980.6	28.96	339.5	1.783	.602 9
400	400	12.40	285.55	966.1	724.	1.179	980.5	28.96	338.8	1.777	.600 4
600	600	11.10	284.25	943.2	707.	1.156	980.5	28.96	338.0	1.771	.598 0
800	800	9.80	282.95	920.8	691.	1.134	980.4	28.96	337.2	1.764	.595 5
1 000	1 000	8.50	281.65	898.8	674.	1.112	980.4	28.96	336.4	1.758	.593 1
1 200	1 200	7.20	280.35	877.2	658.	1.090	980.3	28.96	335.7	1.752	.590 6
1 400	1 400	5.90	279.05	856.0	642.	1.069	980.2	28.96	334.9	1.745	.588 1
1 600	1 600	4.60	277.75	835.3	627.	1.048	980.2	28.96	334.1	1.739	.585 7
1 800	1 799	3.30	276.45	814.9	611.	1.027	980.1	28.96	333.3	1.732	.583 2
2 000	1 999	2.00	275.15	795.0	596.	1.007	980.0	28.96	332.5	1.726	.580 7
2 200	2 199	0.70	273.86	775.5	582.	0.987	980.0	28.96	331.7	1.720	.578 4
2 400	2 399	−0.59	272.56	756.3	567.	0.967	979.9	28.96	331.0	1.713	.575 9
2 600	2 599	−1.89	271.26	737.6	553.	0.947	979.9	28.96	330.2	1.707	.573 3
2 800	2 799	−3.19	269.96	719.2	539.	0.928	979.8	28.96	329.4	1.700	.570 8
3 000	2 999	−4.49	268.66	701.2	526.	0.909	979.7	28.96	328.6	1.694	.568 3
3 200	3 198	−5.79	267.36	683.6	513.	0.891	979.7	28.96	327.8	1.687	.565 8
3 400	3 398	−7.09	266.06	666.3	500.	0.872	979.6	28.96	327.0	1.681	.563 4
3 600	3 598	−8.39	264.76	649.4	487.	0.854	979.6	28.96	326.2	1.674	.560 9
3 800	3 798	−9.69	263.47	632.8	475.	0.837	979.5	28.96	325.4	1.668	.558 4
4 000	3 997	−10.98	262.17	616.6	462.	0.819	979.4	28.96	324.6	1.661	.555 9
4 200	4 197	−12.3	260.87	600.7	451.	0.802	979.4	28.96	323.8	1.655	.553 4
4 400	4 397	−13.6	259.57	585.2	439.	0.785	979.3	28.96	323.0	1.648	.550 8
4 600	4 597	−14.9	258.27	570.0	428.	0.769	979.3	28.96	322.2	1.642	.548 3
4 800	4 796	−16.2	256.97	555.1	416.	0.752	979.2	28.96	321.4	1.635	.545 8
5 000	4 996	−17.5	255.68	540.5	405.	0.736	979.1	28.96	320.5	1.628	.543 3
5 200	5 196	−18.8	254.38	526.2	395.	0.721	979.1	28.96	319.7	1.622	.540 8
5 400	5 395	−20.1	253.08	512.3	384.	0.705	979.0	28.96	318.9	1.615	.538 3
5 600	5 595	−21.4	251.78	498.6	374.	0.690	978.9	28.96	318.1	1.608	.535 7
5 800	5 795	−22.7	250.48	485.2	364.	0.675	978.9	28.96	317.3	1.602	.533 2

8.8 Cutin and Cutout Wind Speeds

For the purpose of this report, a cutin wind speed of 6.6 m/s (15 mph) and a cutout wind speed of 15.65 m/s (35 mph) was used unless where specified. These parameters affect only the estimated output energy and do not reflect the operating parameters of the control system at any of the turbine sites.

These parameters are used to calculate theoretical energy. They are the same for each prospecting site to facilitate comparison. In addition, the estimated output energy was calculated for a cutout wind speed of 17.88 m/s (40 mph). This information is displayed on the graphs of turbine theoretical energy but is not listed in the Sites' Performance Summary Data Sheet (report on Turbine Sites).

8.9 Standard Deviations of Monthly Average Wind Speed and Monthly Weibull Parameter K

Table 3 is presented to assist in evaluating fluctuations in the monthly average wind speeds and K-value. These tables may be used in conjunction with the graphs of average wind speed and K-value. The mean of the monthly average wind speeds V_{av} for each site is given with its standard deviation. The mean of the monthly K-value (K_{av}) is also listed by site with its standard deviation.

V_a and K_a values are included for each site over a period of time corresponding as closely as data would permit to a calendar year.

It should be emphasized that the values K_{av}, V_{av} differ from K_a, V_a although these numbers were computed from the same data over the same time period. The mean of the monthly average wind speeds may not be the same as the average wind speed for the same period.

Similarly, by definition, the mean of the monthly K-values is not the same as the K-value for the entire time period.

9. RESULTS

Table 3 summarizes the average yearly wind speed and Weibull K values described in previous sections of the report for each of the generating sites monitored during the calendar year 1987 and for those sites monitored during previous years of this program.

Detailed performance data for 1987, for each site providing data in 1987/88, including plots of frequency of occurrence vs. windspeed, and probability vs. windspeed are included in the sites' appendix.

TABLE 3

Yearly Summaries

SITE NAME	YEAR	DATA PERIOD hours	PERIOD % OF TOTAL TIME %	Vav m/s	Kav	AES Vav m/s	Va m/s	Ka	ESTIMATED OUTPUT NO DOWN-TIME NO CUTOUT KW-HR	AVAILABLE WIND ENERGY BETZ LIMIT KW-HR
********** EAST COAST **********										
ATLANTIC TEST SITE	1982	3095.60	35.34	6.72	2.34	4.90	6.67	1.92	24543.20	83689.00
	1983	7853.90	89.66	5.72	1.98	4.90	5.80	1.66	41859.10	145223.00
	1984	5013.10	57.07	5.53	1.78	4.90	5.40	1.44	28578.60	105542.00
	1985	7822.40	89.30	6.48	1.96	4.90	6.55	1.68	59972.70	217958.00
FRENCH LAKES	1983	7145.50	81.57	5.02	1.65	6.00	5.08	1.57	23472.30	130756.00
SURGE LAKE	1982	4897.20	55.90	7.34	1.86	6.70	7.27	1.73	48994.20	196813.00
	1983	8142.20	92.95	7.21	1.82	6.70	7.20	1.72	82157.60	318520.00
WEST DALHOUSIE	1982	8204.20	93.66	4.57	1.69	4.40	4.29	1.52	18211.80	79395.00
	1983	7768.50	88.68	4.25	1.68	4.40	4.23	1.48	14814.40	62914.00
UNIVERSITY STE ANNE	1986	2758.80	31.49	6.02	1.92	4.95	5.56	1.69	21525.00	66907.00
	1987	8775.60	100.00	5.52	1.92	4.95	5.50	1.54	48082.10	162292.00
ST. ANTHONY	1986	5724.50	65.35	8.02	2.18	5.66	8.10	2.00	79281.40	275594.00
********** ONTARIO **********										
FORT SEVERN	1982	4430.30	50.57	4.90	2.03	5.10	4.96	1.97	9826.90	45948.00
NRC OTTAWA	1981	5334.00	60.89	3.27	1.59	3.80	3.40	1.49	2579.00	20453.00
	1982	8540.40	97.49	3.65	1.65	3.80	3.49	1.51	7813.03	45010.00
	1983	8838.00	100.00	3.56	1.74	3.80	3.55	1.58	5345.70	37189.00
	1984	8681.20	98.83	3.31	1.64	3.80	3.53	1.42	5874.10	37163.00
PELEE ISLAND	1980	3528.70	40.17	6.42	1.94	4.70	6.50	1.84	23779.30	87273.00
	1981	4079.00	46.56	5.60	1.77	4.70	5.70	1.36	18646.00	76819.00
	1982									
	1983									
	1984	8552.70	97.37	5.74	1.92	4.70	5.69	1.72	45339.90	164214.00
WINISK	1980	2518.20	28.67	6.60	2.04	5.10	6.60	1.96	16146.20	63252.00
	1981	8321.30	94.99	5.29	2.02	5.10	5.30	1.75	26853.00	95746.00

TABLE 3 (cont'd)

Yearly Summaries

SITE NAME	YEAR	DATA PERIOD hours	PERIOD % OF TOTAL TIME %	Vav m/s	Kav	AES Vav m/s	Va m/s	Ka	ESTIMATED OUTPUT NO DOWN-TIME NO CUTOUT KW-HR	AVAILABLE WIND ENERGY BETZ LIMIT KW-HR
	1982	5379.70	61.41	5.78	1.93	5.10	5.55	1.76	19159.50	84942.00
********** CENTRAL CANADA **********										
ARCOLA	1984	4843.20	55.14	6.31	1.78	5.80	6.21	1.63	32530.40	125372.00
GARDINER DAM	1984	2919.10	33.23	5.83	2.00	4.30	5.93	1.72	17271.60	60495.00
	1985	2131.70	24.33	4.30	1.92	4.30	3.74	1.57	4899.70	18796.00
SHAGANAPPI WIND RANCH	1984	7452.30	84.84	4.16	1.48	4.50	4.19	1.36	18027.00	71267.00
********** WEST COAST **********										
BAMFIELD	1982	4735.10	54.05	4.52	1.15	3.30	4.41	1.11	17843.40	76819.00
	1983	8757.40	99.97	4.45	1.43	3.30	4.43	1.20	27288.40	104917.00
CHRISTOPHER POINT (lower)	1981	7189.00	82.07	5.20	1.66	4.90	5.00	1.52	24123.00	109007.00
	1982	7601.00	86.77	5.77	1.81	4.90	5.94	1.69	40698.60	164927.00
	1983	7333.30	83.71	6.02	1.97	4.90	6.03	1.75	42527.00	159464.00
	1984	8606.50	97.98	5.73	1.65	4.90	5.29	1.40	44187.90	166174.00
CHRISTOPHER POINT (upper)	1981	8966.00	100.00	5.58	1.63	4.90	5.50	1.51	54154.30	178807.00
	1982	7764.00	88.63	4.54	1.34	4.90	4.71	1.24	45341.40	181824.00
	1983	7018.60	80.12	3.18	0.99	4.90	3.03	0.91	33255.40	13880.60
	1984	2341.30	26.65	2.00	0.82	4.90	1.67	0.86	4227.00	16561.00
KITKATLA	1984	2837.10	32.30	8.08	2.85	4.90	8.09	1.95	37666.20	137238.00

TABLE 3 (cont'd)

Yearly Summaries

SITE NAME	YEAR	DATA PERIOD hours	PERIOD % OF TOTAL TIME %	Vav m/s	Kav	AES Vav m/s	Va m/s	Ka	ESTIMATED OUTPUT NO DOWN-TIME NO CUTOUT KW-HR	AVAILABLE WIND ENERGY BETZ LIMIT KW-HR
NASSET (upper)	1982	8208.30	93.70	6.31	1.87	4.60	6.36	1.72	50246.90	212071.00
	1983	5070.80	57.89	5.97	1.85	4.60	5.87	1.70	26965.90	94703.00
	1984	5197.10	59.17	6.90	1.70	4.60	6.98	1.74	45457.90	135771.00
	1985	4606.30	52.58	6.48	2.05	4.60	6.50	1.97	27769.70	99668.00
NASSET (lower)	1982	5463.20	62.37	5.14	1.71	4.60	5.62	1.63	22626.70	102237.00
	1983		0.00							
	1984	9264.30	100.00	4.83	1.54	4.90	4.82	1.34	27504.70	112375.00
	1985	7160.40	81.74	4.52	1.55	4.90	4.64	1.36	16879.20	73461.00
SANDSPIT (Beban)	1982	11419.30	130.36	4.12	1.06	4.60	4.20	0.80	18980.30	100346.00
	1983	4589.10	52.39	4.68	1.16	4.60	4.40	0.92	22859.40	94964.00
	1984	4813.10	54.79	5.07	1.02	4.90	5.27	0.94	28930.10	133991.00
SANDSPIT (lower)	1983	5582.50	63.73	5.03	1.46	4.60	5.03	1.17	25183.00	115175.00
	1984	454.00	5.17	6.40	1.18	4.90	6.40	1.18	3437.50	19586.00
	1985	4954.30	56.56	4.96	1.50	4.90	5.15	1.43	19026.10	76177.00
SANDSPIT (upper)	1983	10237.70	116.87	5.70	1.38	4.60	5.88	1.28	62927.60	291445.00
	1984	8205.00	93.41	6.12	1.41	4.90	6.08	1.29	55540.50	250589.00
TLELL	1983	6902.10	78.79	5.19	1.28	4.60	5.13	1.06	42478.60	167673.00
	1984	4148.20	47.22	5.52	1.21	4.90	5.54	1.02	25582.90	136584.00
WALTERS COVE	1983	7008.30	80.00	2.37	1.13	4.00	2.29	0.88	11291.30	41766.00
RATTLESNAKE HILL	1986	2622.30	29.93	3.03	1.83	2.30	3.00	1.71	1196.90	11104.00
	1987	8731.70	99.68	3.80	1.76	2.30	3.80	1.63	15269.70	63041.00

TABLE 3 (cont'd)

Yearly Summaries

SITE NAME	YEAR	DATA PERIOD hours	PERIOD % OF TOTAL TIME %	Vav m/s	Kav	AES Vav m/s	Va m/s	Ka	ESTIMATED OUTPUT NO DOWN-TIME NO CUTOUT KW-HR	AVAILABLE WIND ENERGY BETZ LIMIT KW-HR
********** NORTHERN CANADA **********										
CAMBRIDGE BAY	1984	4019.90	45.76	6.00	2.05	6.10	5.84	1.75	23390.90	100617.00
	1985	2427.00	27.71	6.00	2.40	6.10	5.95	2.23	12543.50	43011.00
DESTRUCTION BAY	1982	8609.40	98.28	5.44	1.54	2.90	5.16	1.49	45215.20	177537.00
RANKIN INLET	1984	958.40	10.91	8.20	2.62	6.19	7.72	2.21	10516.30	37350.00
	1985	4344.20	49.59	7.80	1.95	6.19	7.72	1.71	50556.70	21551.00
	1986	6656.80	75.99	6.40	1.90	6.19	6.70	1.63	64776.60	244804.00
	1987	2784.00	31.78	6.76	1.77	6.19	6.73	1.68	33208.50	113880.00

APPENDIX INDEX

Site Name	Appendix
Universite Ste. Anne	A
Rattlesnake Hill	B
Rankin Inlet	C

APPENDIX "A"

Universite Ste. Anne

AIR DENSITY COMPENSATION FACTORS
BASED ON
A.E.S. NORMALS AT THE CLOSEST A.E.S. STATION

SITE: St. Anne University

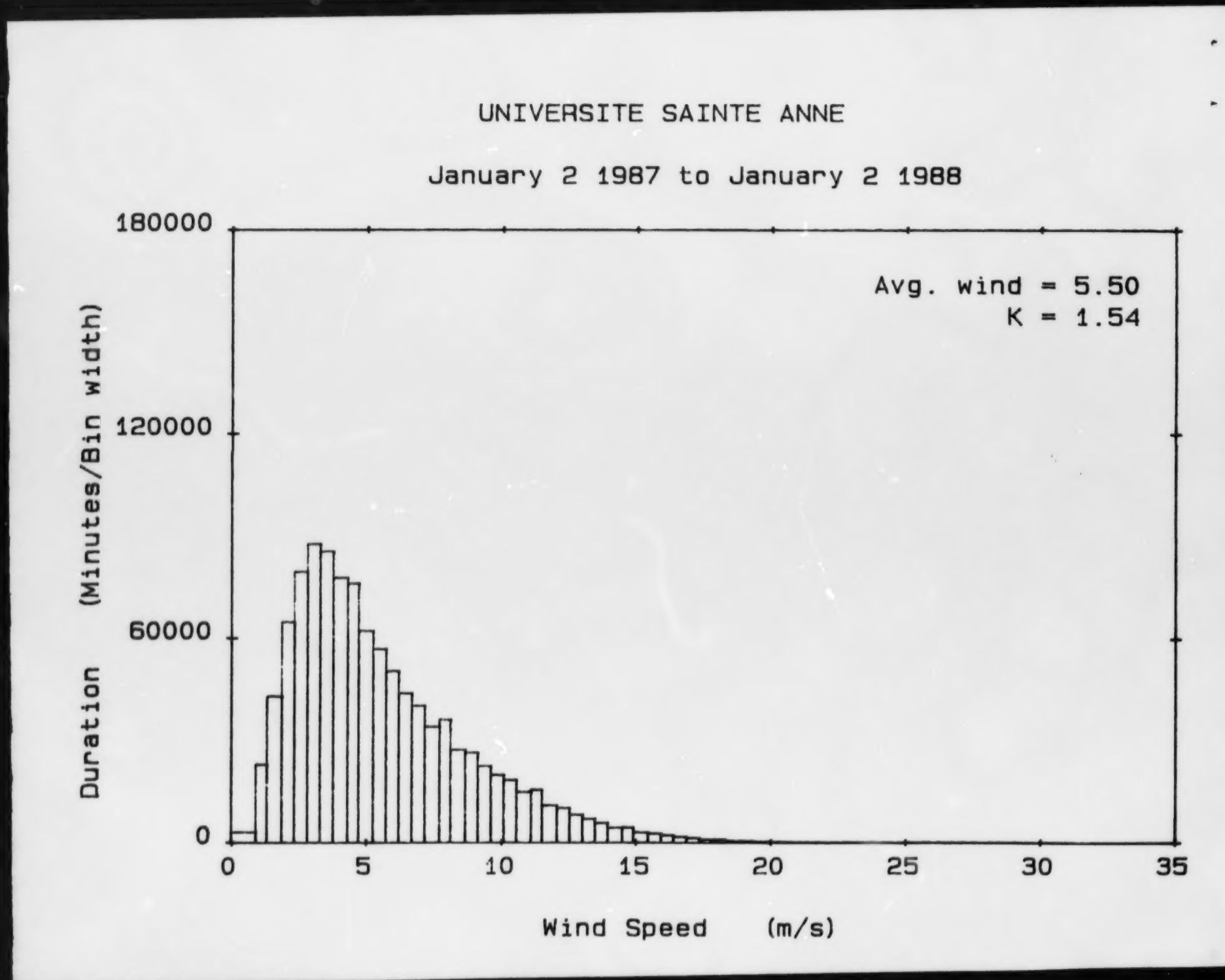
ALTITUDE: 17m **CLOSEST A.E.S. STATION:** Weymouth (Falls) N.S.

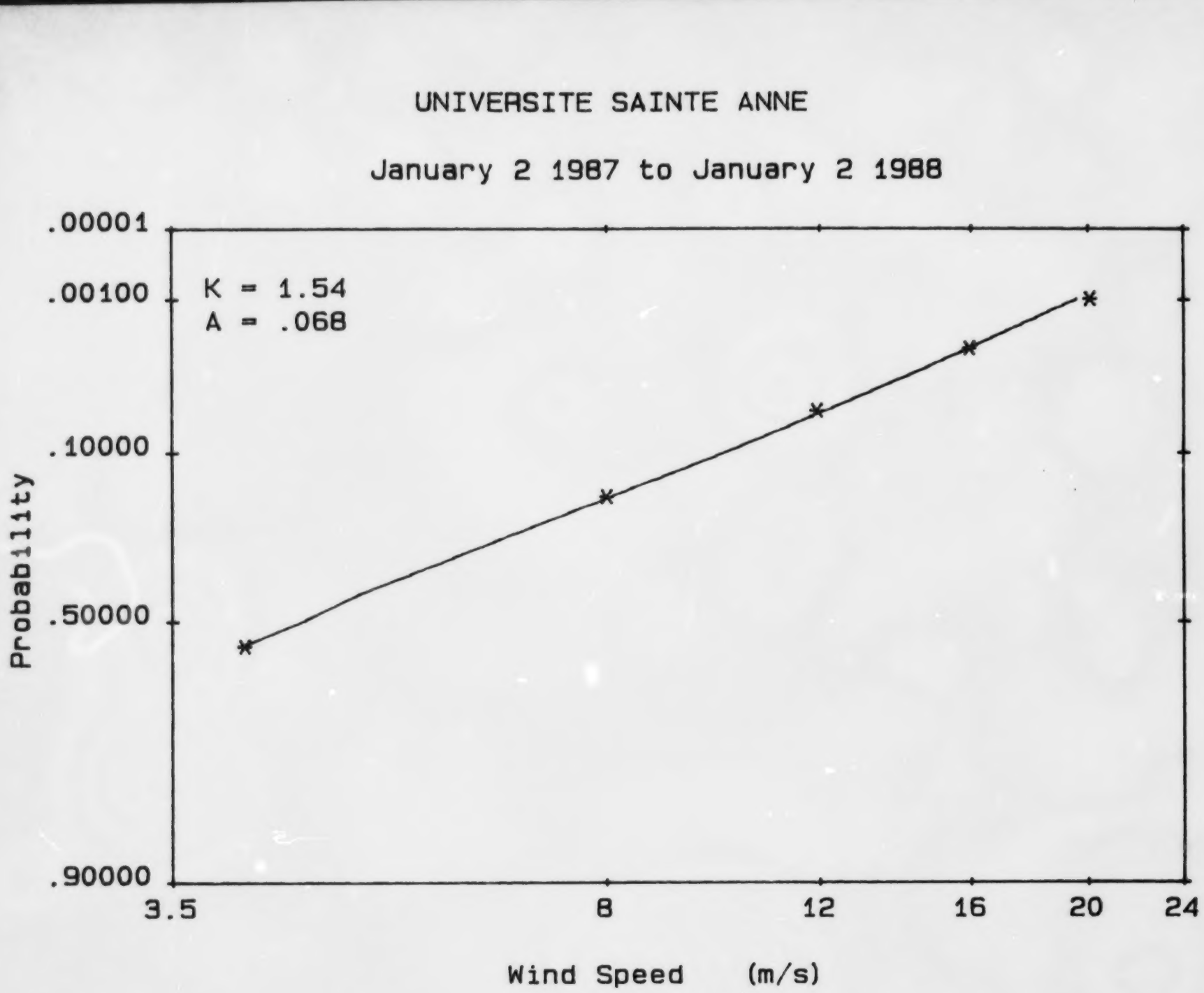
STD AIR PRESSURE: 101.13 kPa

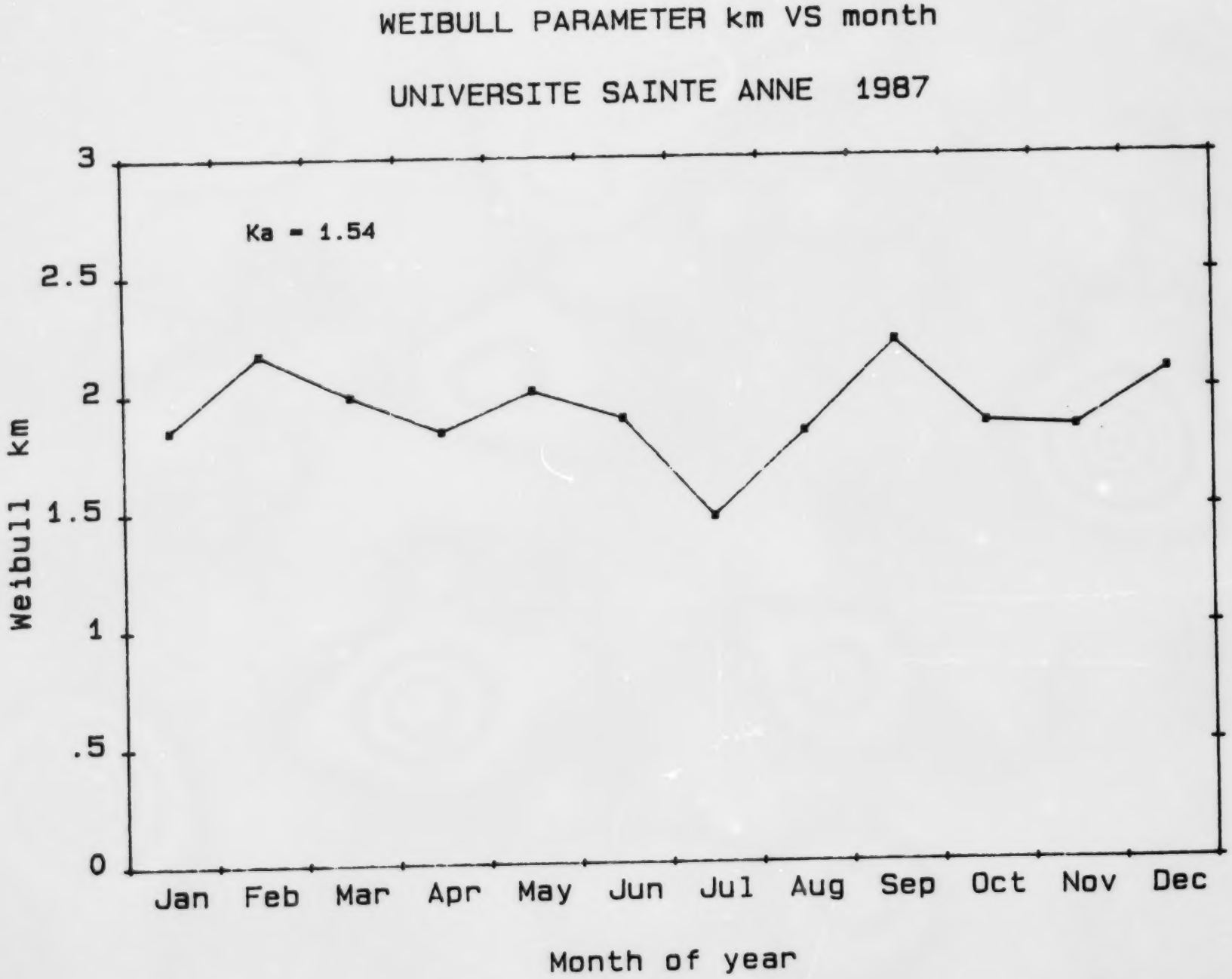
	AVERAGE MONTHLY A.E.S. TEMPERATURE T_{avg} ^{o}K	COMPENSATION FACTOR f_{comp} $f_{comp} = \frac{288.15}{T_{avg}} \times \frac{\text{Std Air Pressure}}{101.33}$
JANUARY	269.8	1.07
FEBRUARY	269.1	1.07
MARCH	273.1	1.05
APRIL	278.0	1.03
MAY	283.5	1.01
JUNE	288.1	1.00
JULY	291.3	0.99
AUGUST	290.7	0.99
SEPTEMBER	287.1	1.00
OCTOBER	282.5	1.02
NOVEMBER	278.1	1.03
DECEMBER	272.1	1.06

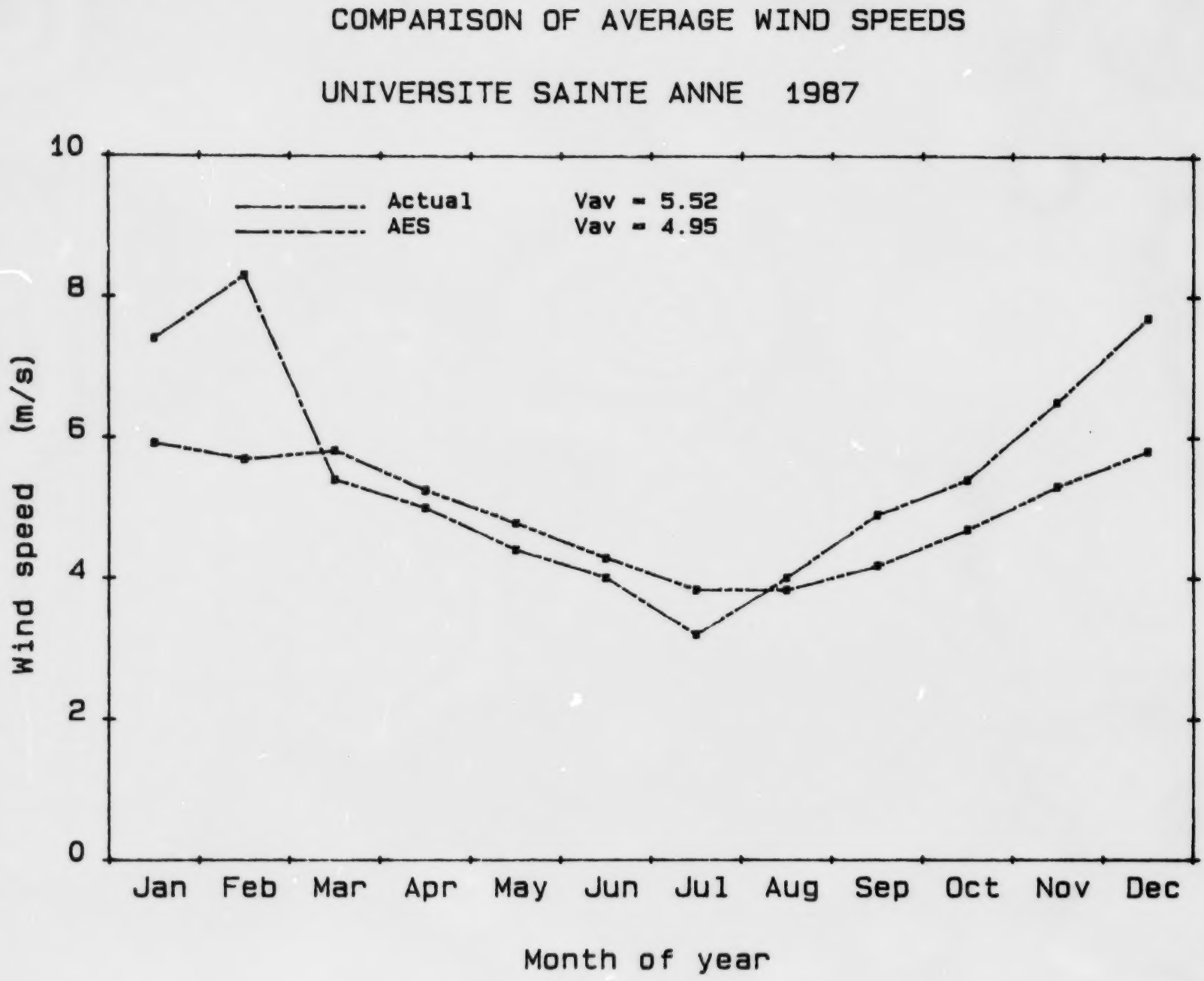
Notes: Compensated Energy Output = Estimated Energy Output x f_{comp}

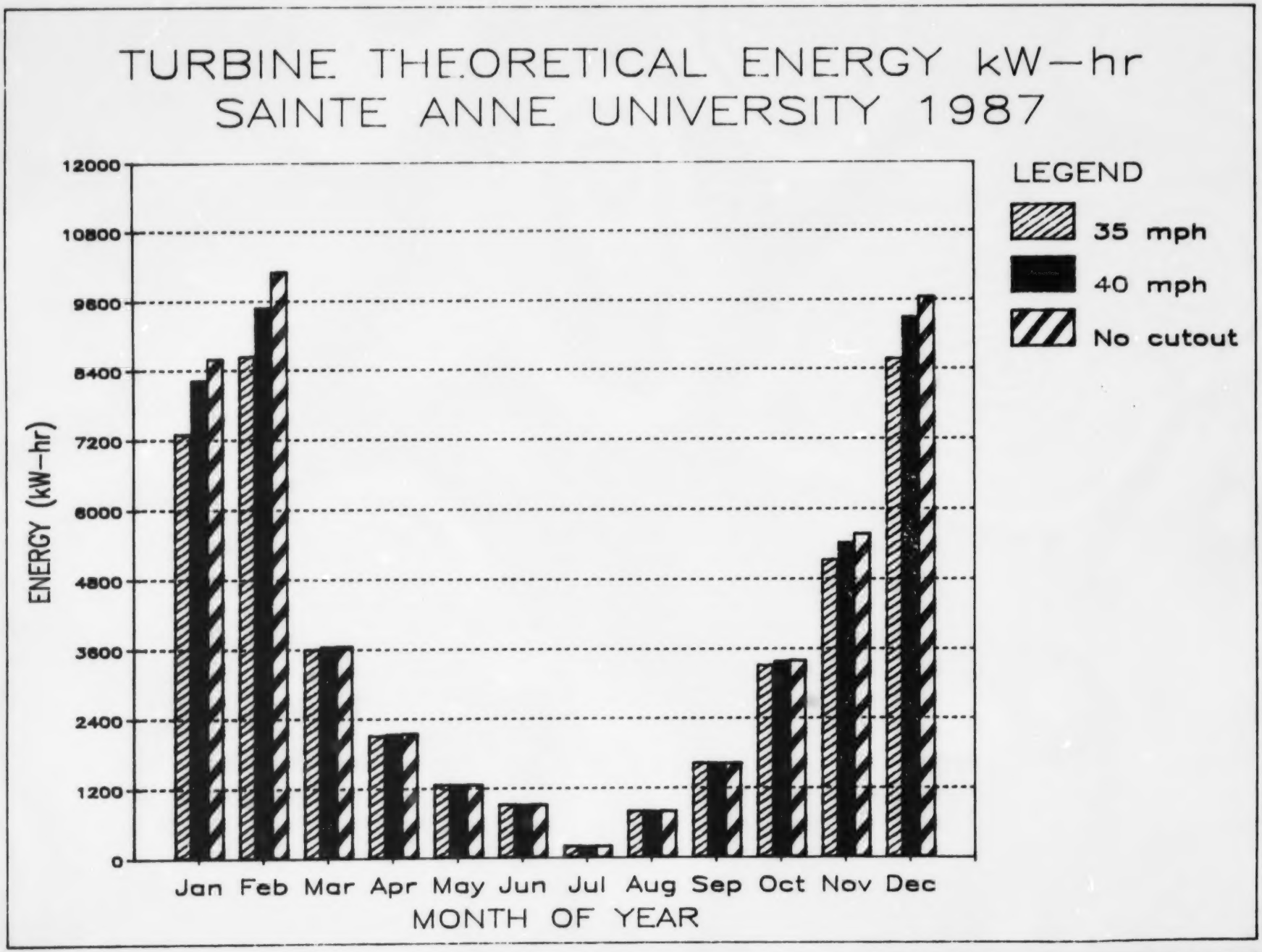
A.E.S. data obtained from Canadian Climate Normals
Temperature 1951 - 1980 UDC: 551.582(71)

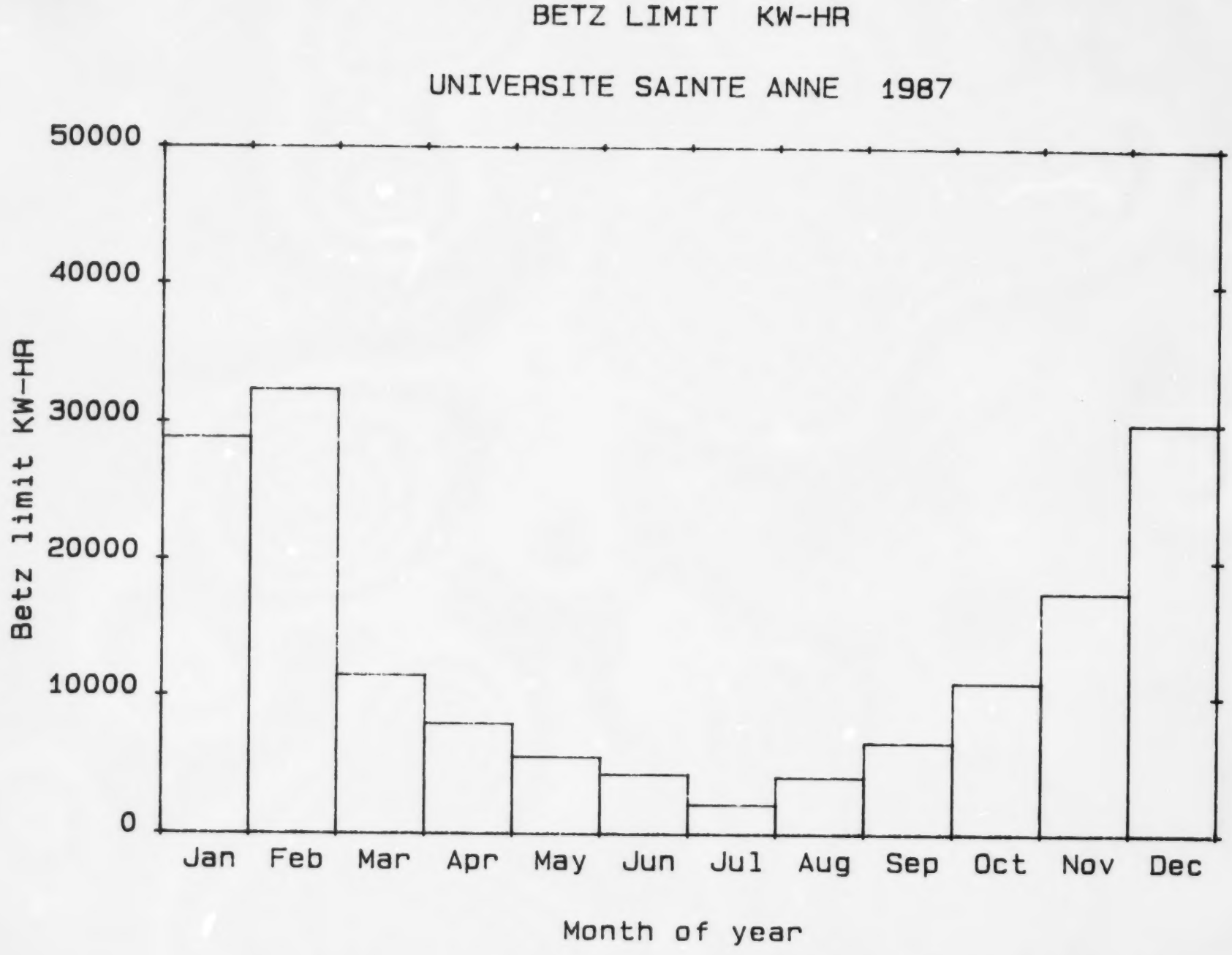

UNIVERSITE SAINTE ANNE
January 2 1987 to January 2 1988
Avg. wind = 5.50
K = 1.54
Duration (Minutes/Bin width)
180000
120000
60000
0
0
5
10
15
20
25
30
35
Wind Speed (m/s)


UNIVERSITE SAINTE ANNE
January 2 1987 to January 2 1988
K = 1.54
A = .068
.00001
.00100
.10000
.50000
.90000
Probability
3.5
8
12
16
20
24
Wind Speed (m/s)


WEIBULL PARAMETER km VS month
UNIVERSITE SAINTE ANNE 1987
Ka = 1.54
Weibull km
3
2.5
2
1.5
1
.5
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month of year


COMPARISON OF AVERAGE WIND SPEEDS
UNIVERSITE SAINTE ANNE 1987
Actual
AES
Vav = 5.52
Vav = 4.95
Wind speed (m/s)
0
2
4
6
8
10
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month of year


TURBINE THEORETICAL ENERGY kW—hr
SAINTE ANNE UNIVERSITY 1987
ENERGY (kW—hr)
12000
10800
9600
8400
7200
6000
4800
3600
2400
1200
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
MONTH OF YEAR
LEGEND
35 mph
40 mph
No cutout


BETZ LIMIT KW-HR
UNIVERSITE SAINTE ANNE 1987
50000
40000
30000
20000
10000
0
Betz limit KW-HR
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month of year

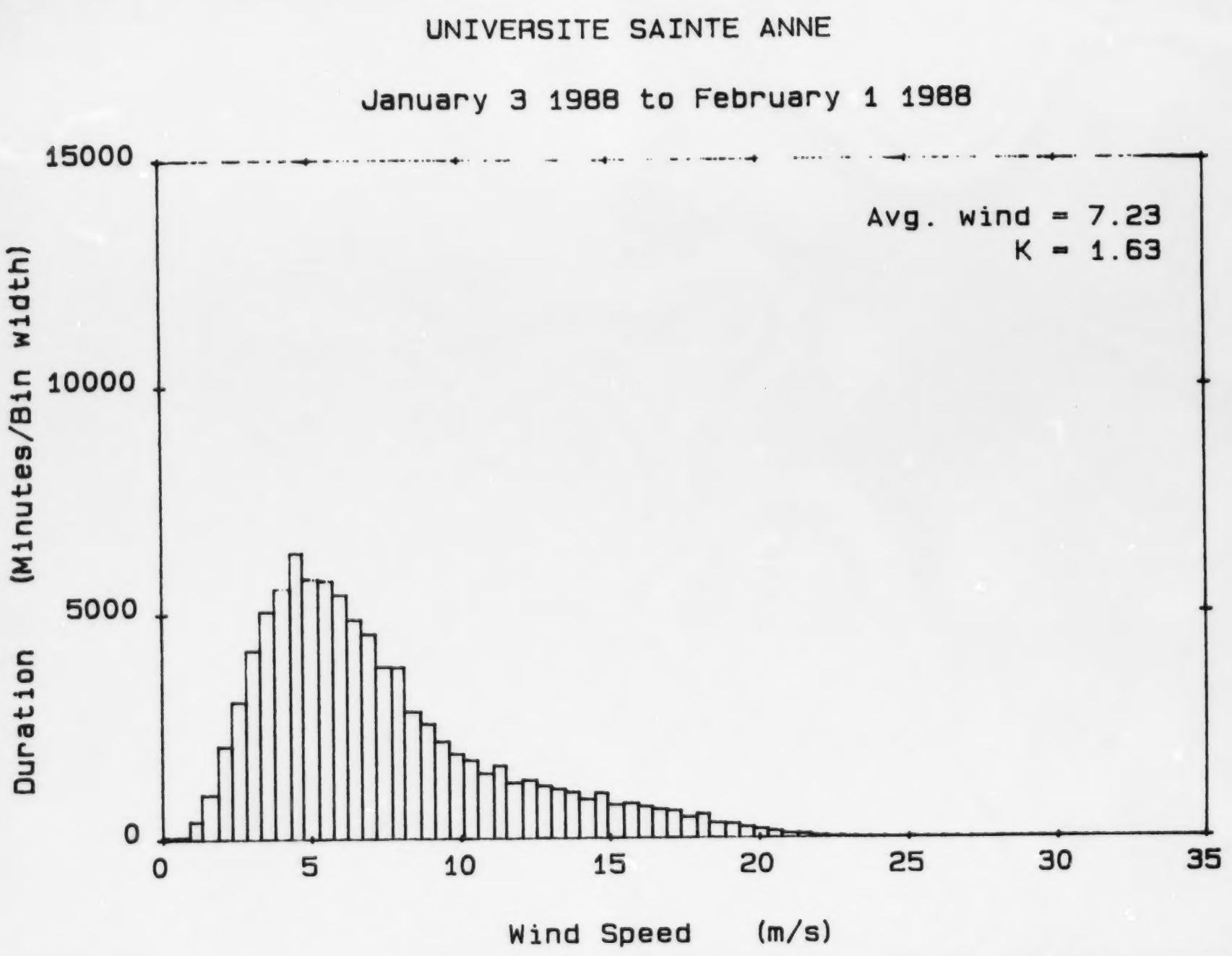
MONTHLY AVERAGE WIND SPEED
AND WEIBULL PARAMETER "K"
AS CALCULATED FROM CONTINUOUSLY
RUNNING WIND HISTOGRAM RECORDER

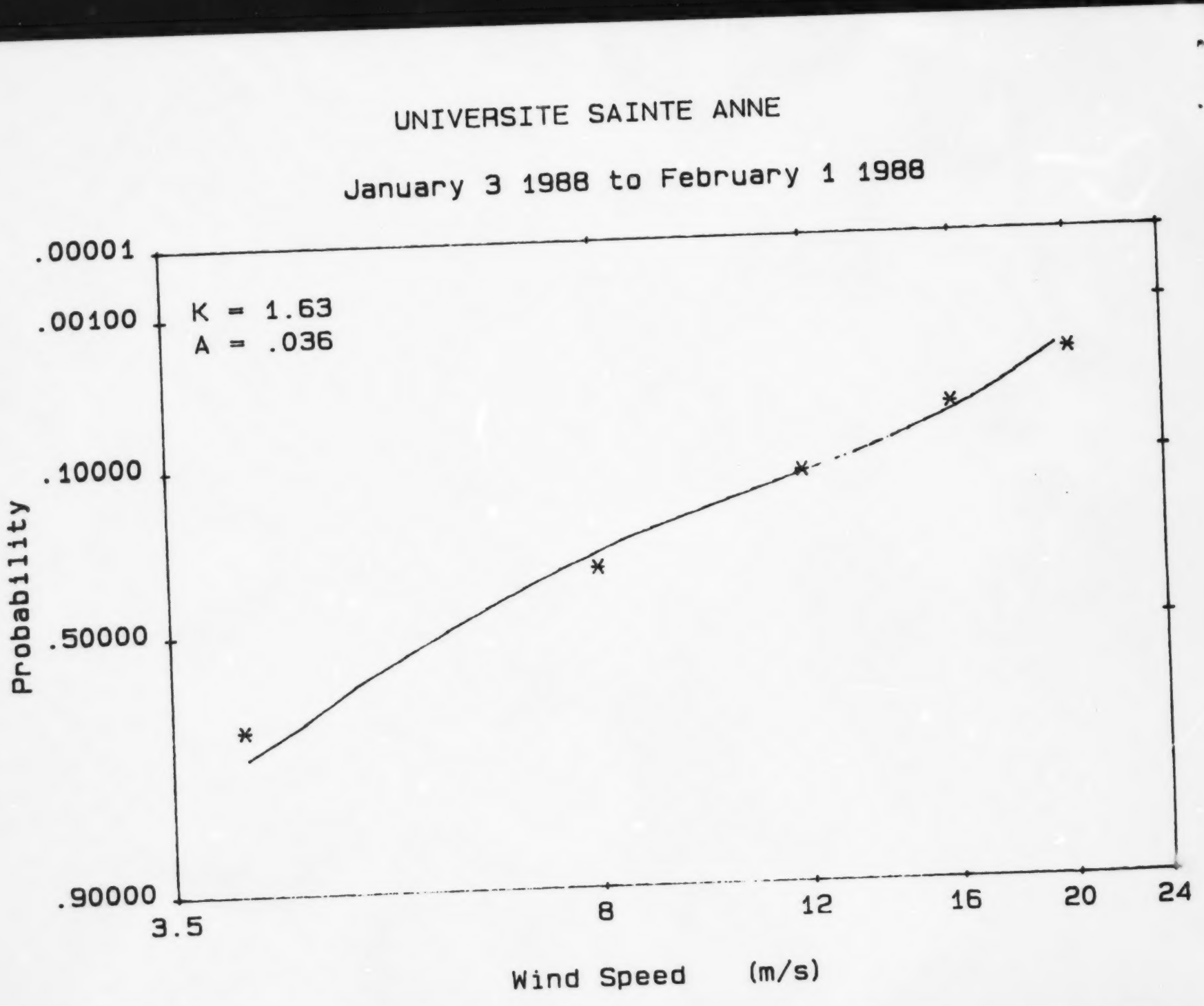
SITE NAME: UNIVERSITE SAINTE ANNE

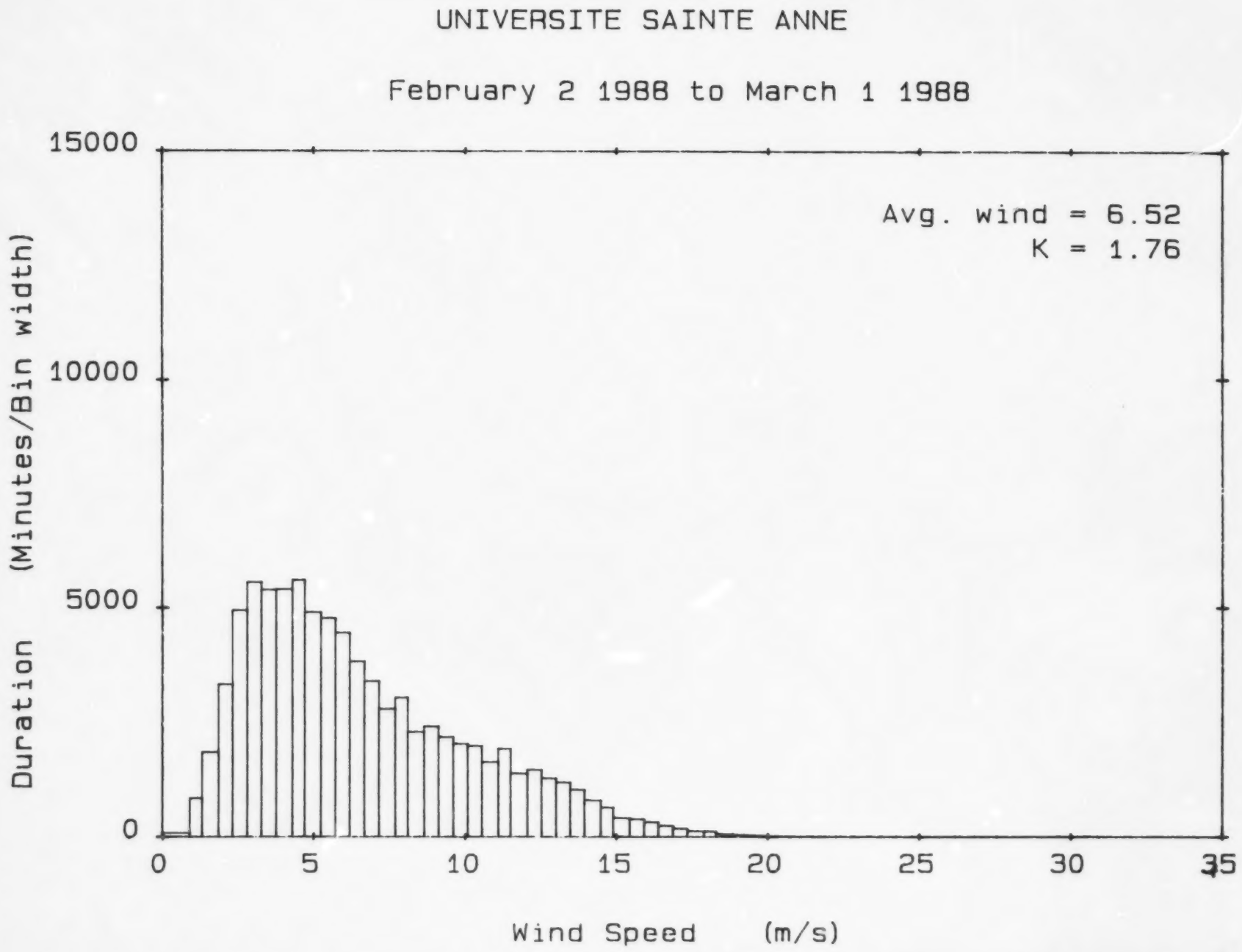
YEAR: 1988

APPROXIMATE MUNTH OF RECORD	TOTAL TIME IN PERIOD HOURS	AVERAGE WIND SPEED M/S	WEIBULL PARAMETER "K"	WEIBULL PARAMETER "A"
January	725.3	7.2	1.63	0.036
February	685.7	6.5	1.76	0.033
March				
April				
May				
June				
July				
August				
September				
October				
November				
December				
YEAR				

Notes:

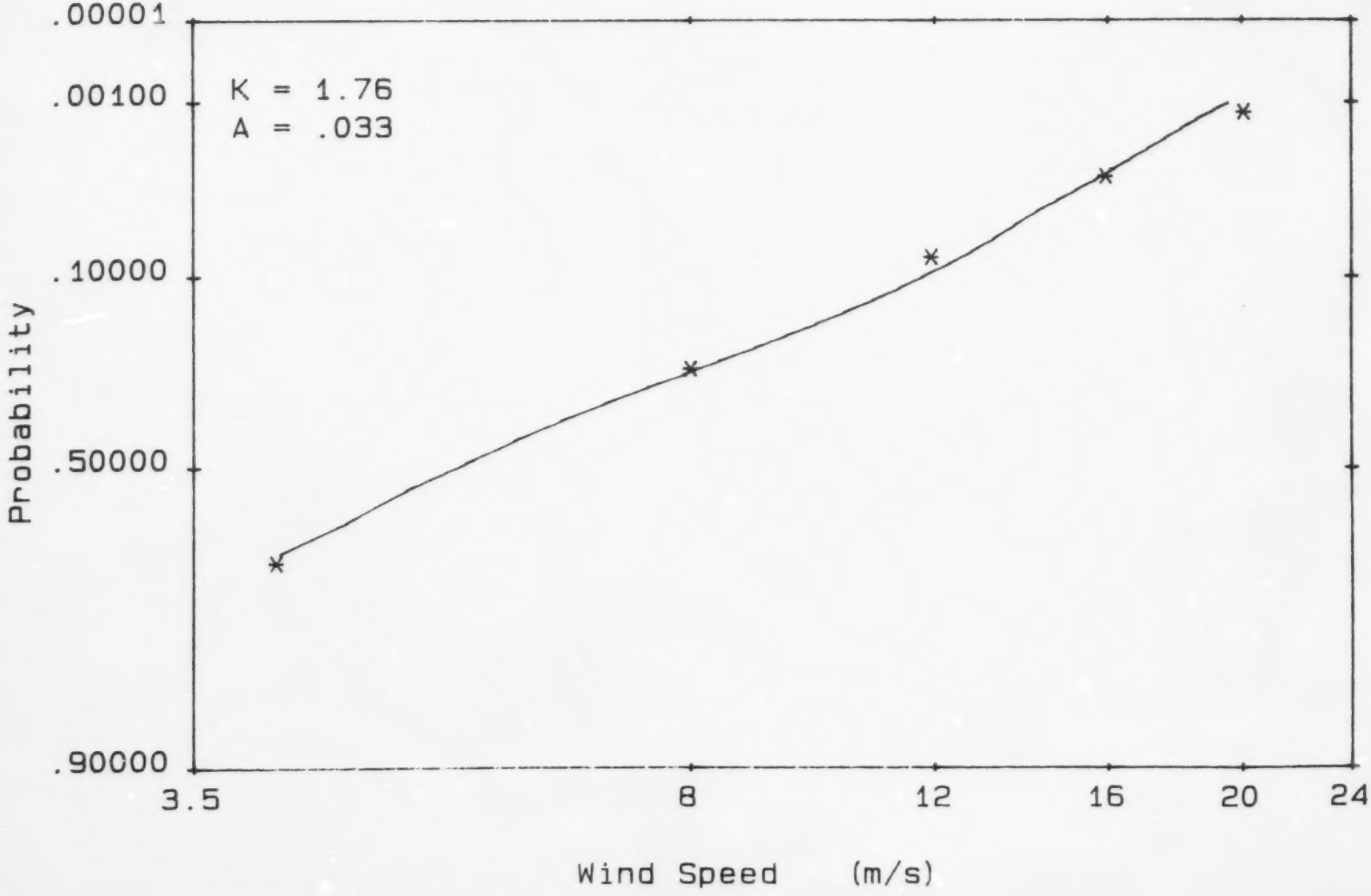

UNIVERSITE SAINTE ANNE
January 3 1988 to February 1 1988
Avg. wind = 7.23
K = 1.63
Duration (Minutes/Bin width)
15000
10000
5000
0
0
5
10
15
20
25
30
35
Wind Speed (m/s)


UNIVERSITE SAINTE ANNE
January 3 1988 to February 1 1988
K = 1.63
A = .036
.00001
.00100
.10000
.50000
.90000
Probability
3.5
8
12
16
20
24
Wind Speed (m/s)


UNIVERSITE SAINTE ANNE
February 2 1988 to March 1 1988
Avg. wind = 6.52
K = 1.76
Duration (Minutes/Bin width)
15000
10000
5000
0
0
5
10
15
20
25
30
35
Wind Speed (m/s)

UNIVERSITE SAINTE ANNE

February 2 1988 to March 1 1988



Site Log: Universite Sainte Anne

Jun. 1986	The site is now operational. It has been erected on the west coast of Nova Scotia at Pointe d'Eglise within ten miles of the Weymouth Falls AES station.
Aug. 1986	Data is now being reported after some difficulties and the replacement of the anemometer, cable and WHR.
Mar. 1988	Site removed from study March 1, 1988.

APPENDIX "B"

Rattlesnake Hill

AIR DENSITY COMPENSATION FACTORS
BASED ON
A.E.S. NORMALS AT THE CLOSEST A.E.S. STATION

SITE: RATTLESNAKE HILL

ALTITUDE: 612 m

CLOSEST A.E.S. STATION: Rattlesnake Hill

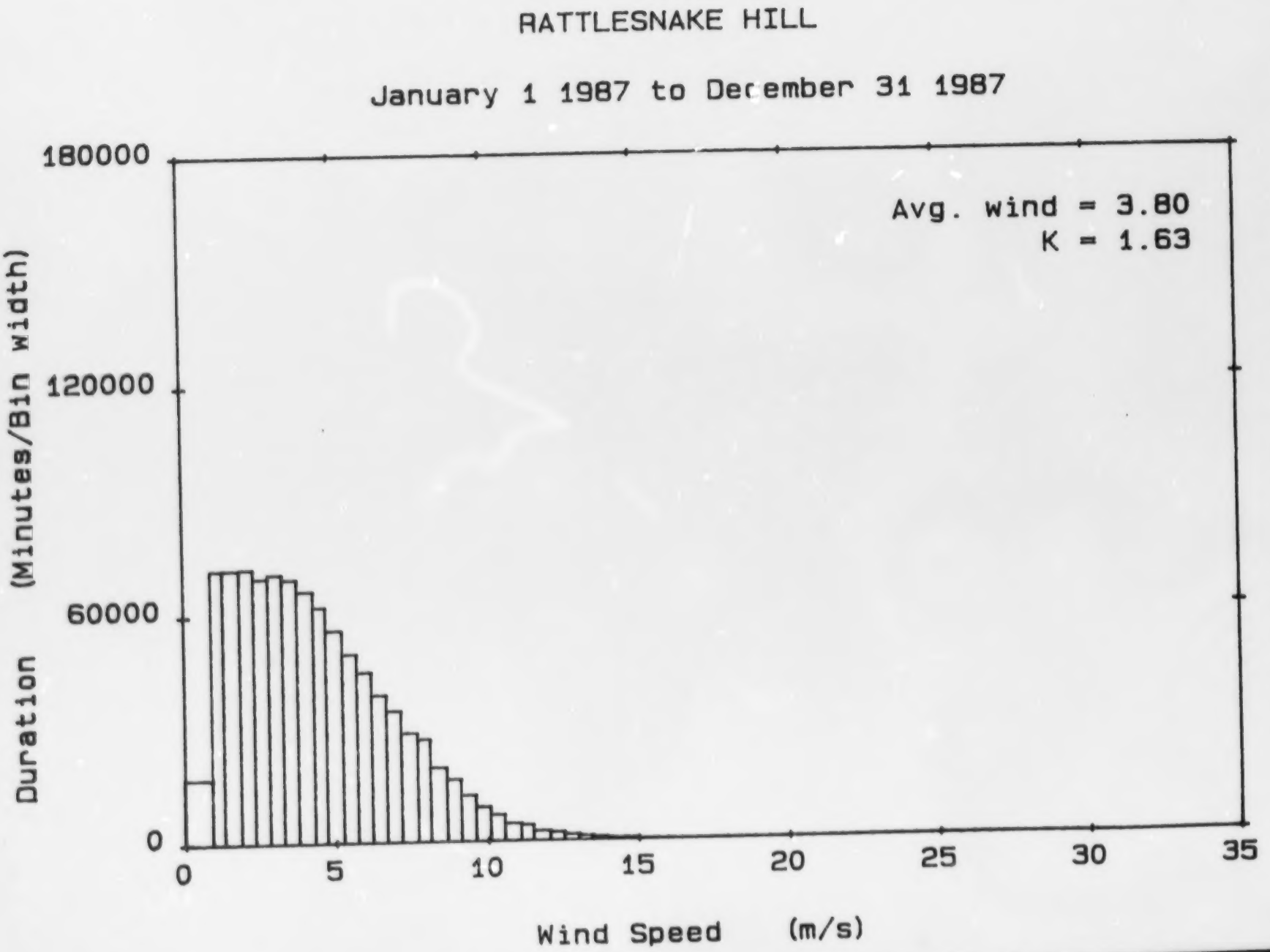
STD AIR PRESSURE: 94.31 kPa

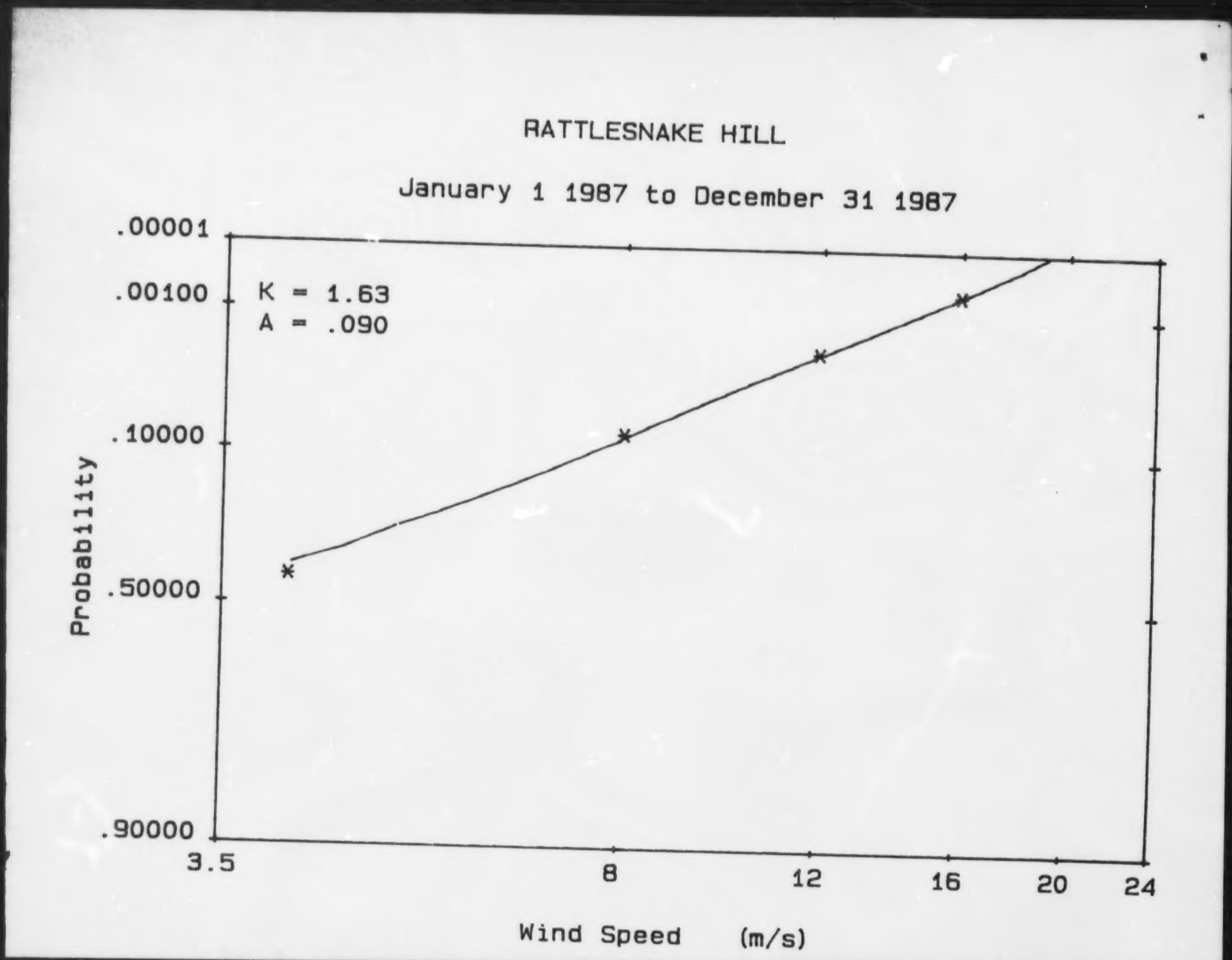
	AVERAGE MONTHLY A.E.S. TEMPERATURE T_{avg} ^{o}K	COMPENSATION FACTOR f_{comp} $f_{comp} = \frac{288.15}{T_{avg}} \times \frac{\text{Std Air Pressure}}{101.33}$
JANUARY	271.1	0.989
FEBRUARY	277.3	0.967
MARCH	283.2	0.947
APRIL	289.8	0.925
MAY	295.3	0.908
JUNE	298.6	0.898
JULY	302.6	0.886
AUGUST	301.3	0.890
SEPTEMBER	296.1	0.906
OCTOBER	287.7	0.932
NOVEMBER	278.7	0.962
DECEMBER	273.6	0.980

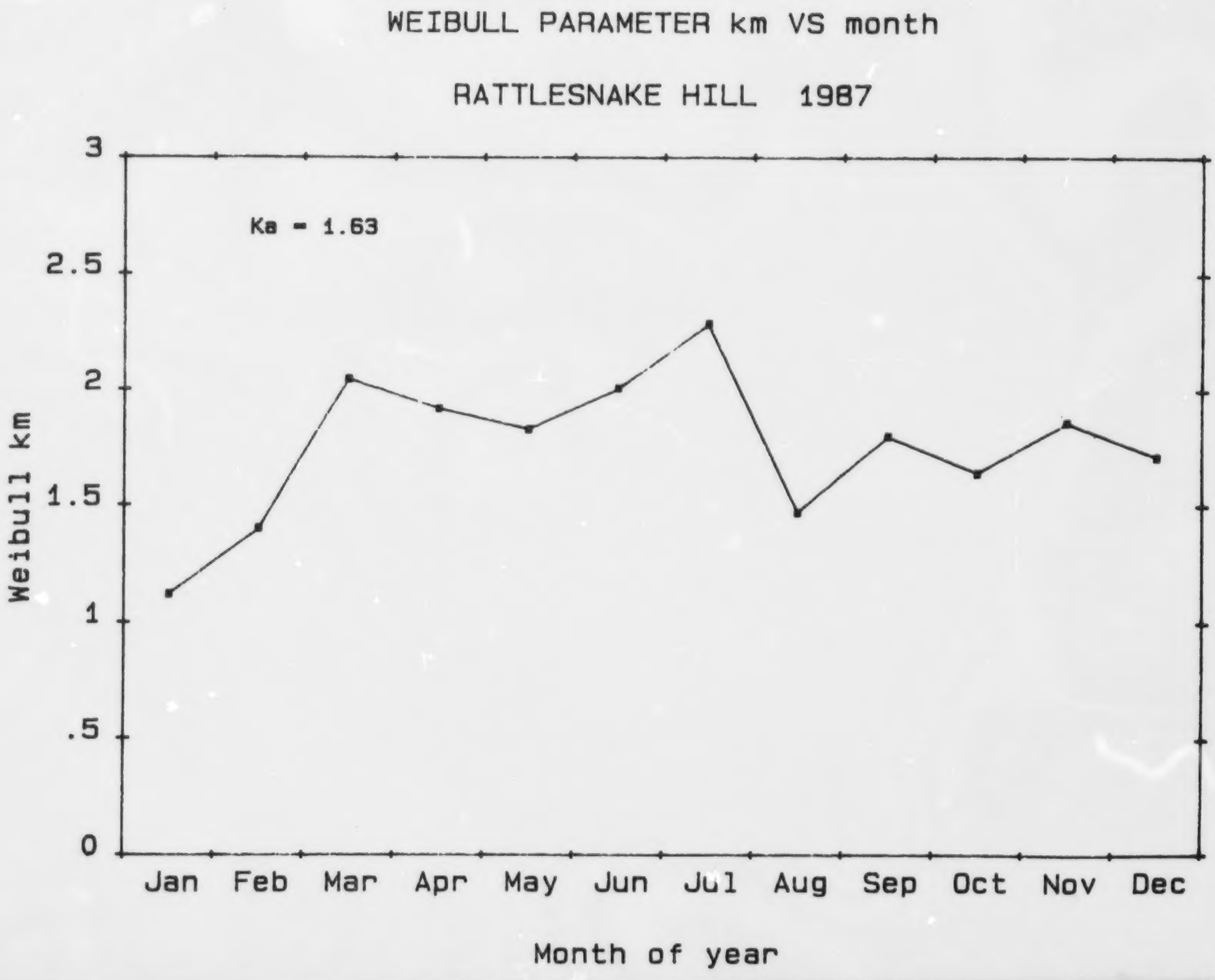
Notes: Compensated Energy Output = Estimated Energy Output x f_{comp}

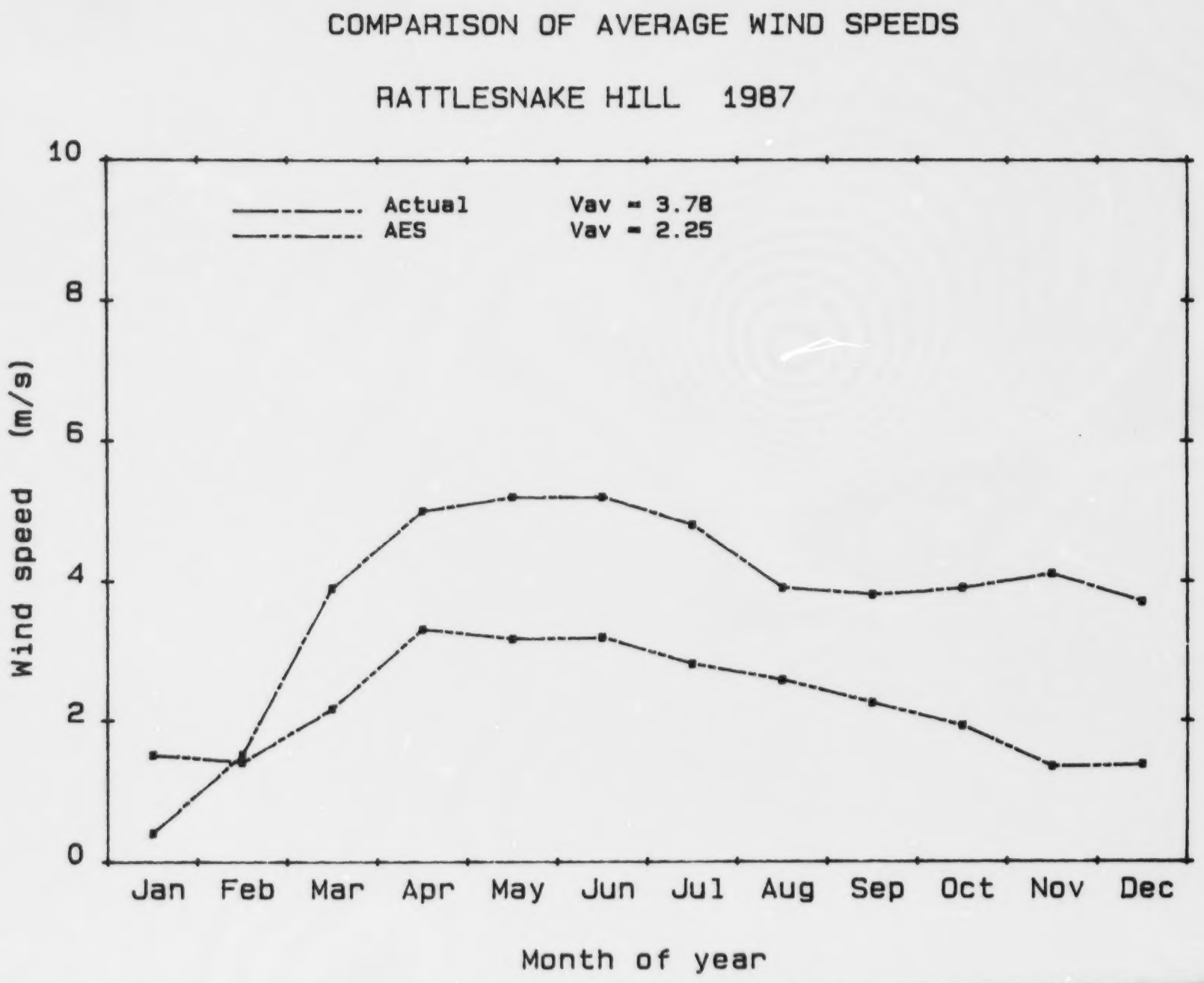
A.E.S. data obtained from Canadian Climate Normals

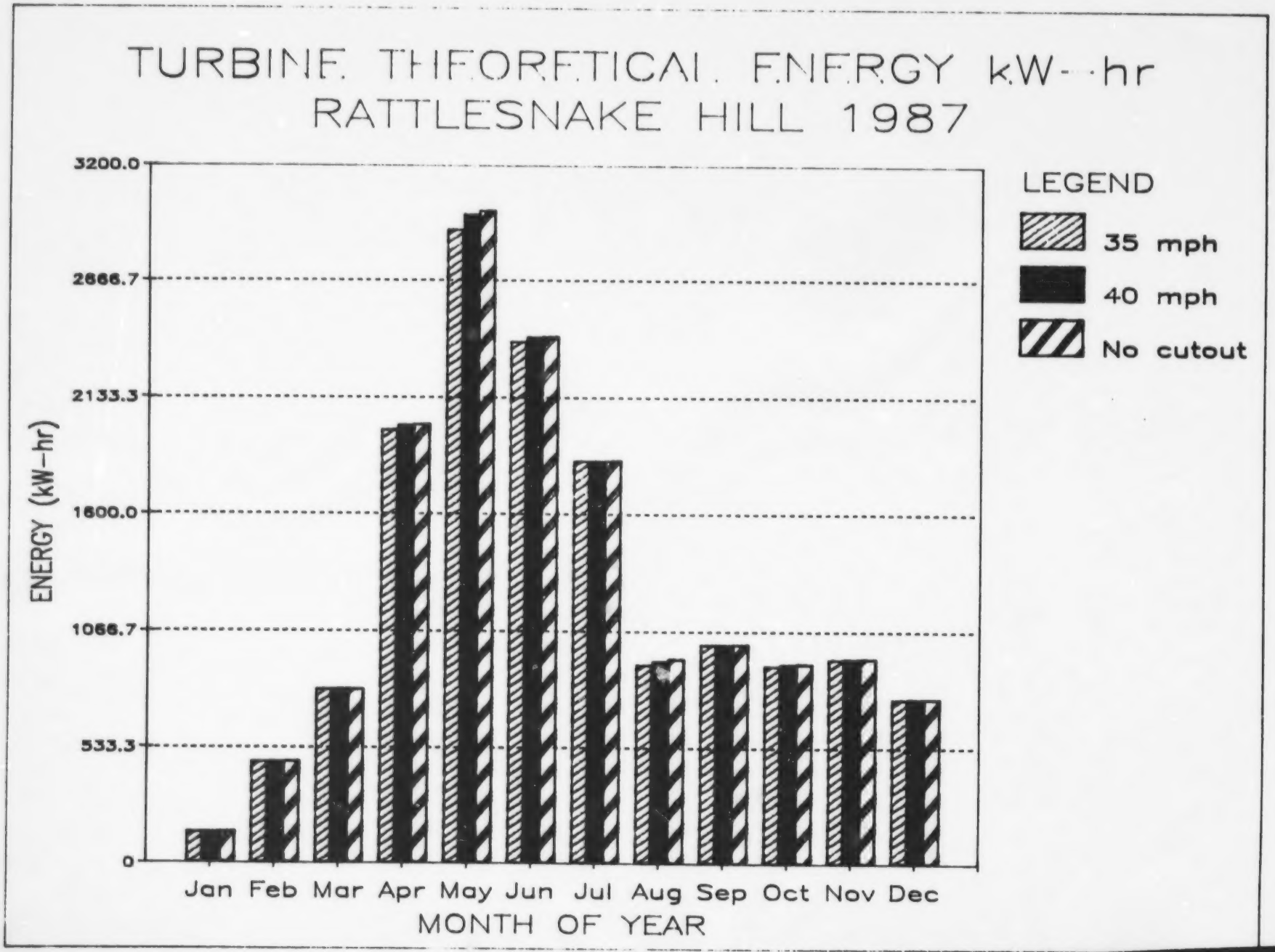
Temperature 1951 - 1980 UDC: 551.582(71)

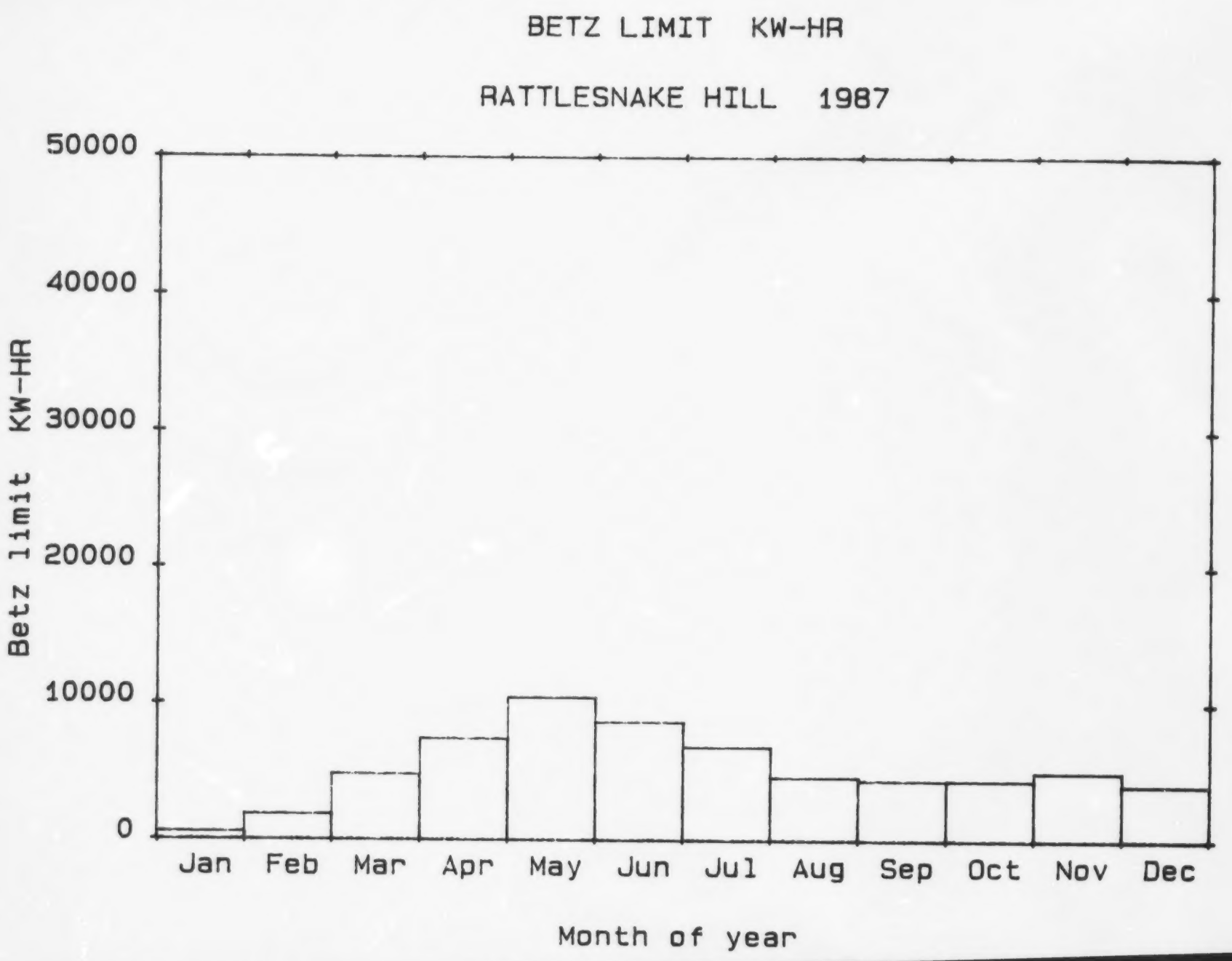

RATTLESNAKE HILL
January 1 1987 to December 31 1987
Avg. wind = 3.80
K = 1.63
180000
120000
60000
0
Duration (Minutes/Bin width)
0
5
10
15
20
25
30
35
Wind Speed (m/s)


RATTLESNAKE HILL
January 1 1987 to December 31 1987
.00001
.00100
.10000
.50000
.90000
K = 1.63
A = .090
Probability
3.5
8
12
16
20
24
Wind Speed (m/s)


WEIBULL PARAMETER km VS month
RATTLESNAKE HILL 1987
Ka = 1.63
Weibull km
3
2.5
2
1.5
1
.5
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month of year


COMPARISON OF AVERAGE WIND SPEEDS
RATTLESNAKE HILL 1987
Actual
AES
Vav = 3.78
Vav = 2.25
Wind speed (m/s)
0
2
4
6
8
10
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month of year


TURBINE THEORETICAL ENERGY kW--hr
RATTLESNAKE HILL 1987
3200.0
2666.7
2133.3
1600.0
1066.7
533.3
0
ENERGY (kW-hr)
LEGEND
35 mph
40 mph
No cutout
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
MONTH OF YEAR


BETZ LIMIT KW-HR
RATTLESNAKE HILL 1987
50000
40000
30000
20000
10000
0
Betz limit KW-HR
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month of year

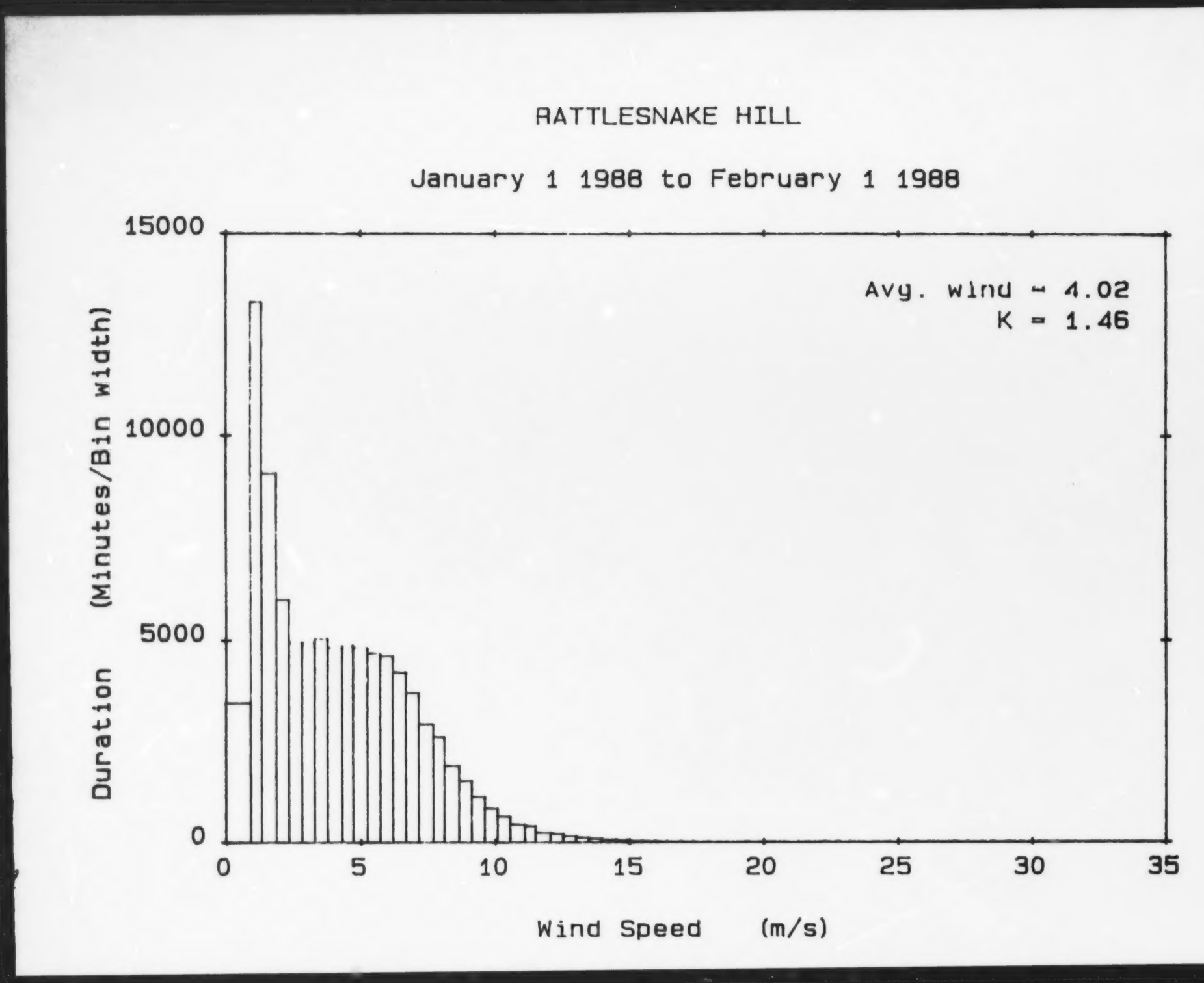
MONTHLY AVERAGE WIND SPEED
AND WEIBULL PARAMETER "K"
AS CALCULATED FROM CONTINUOUSLY
RUNNING WIND HISTOGRAM RECORDER

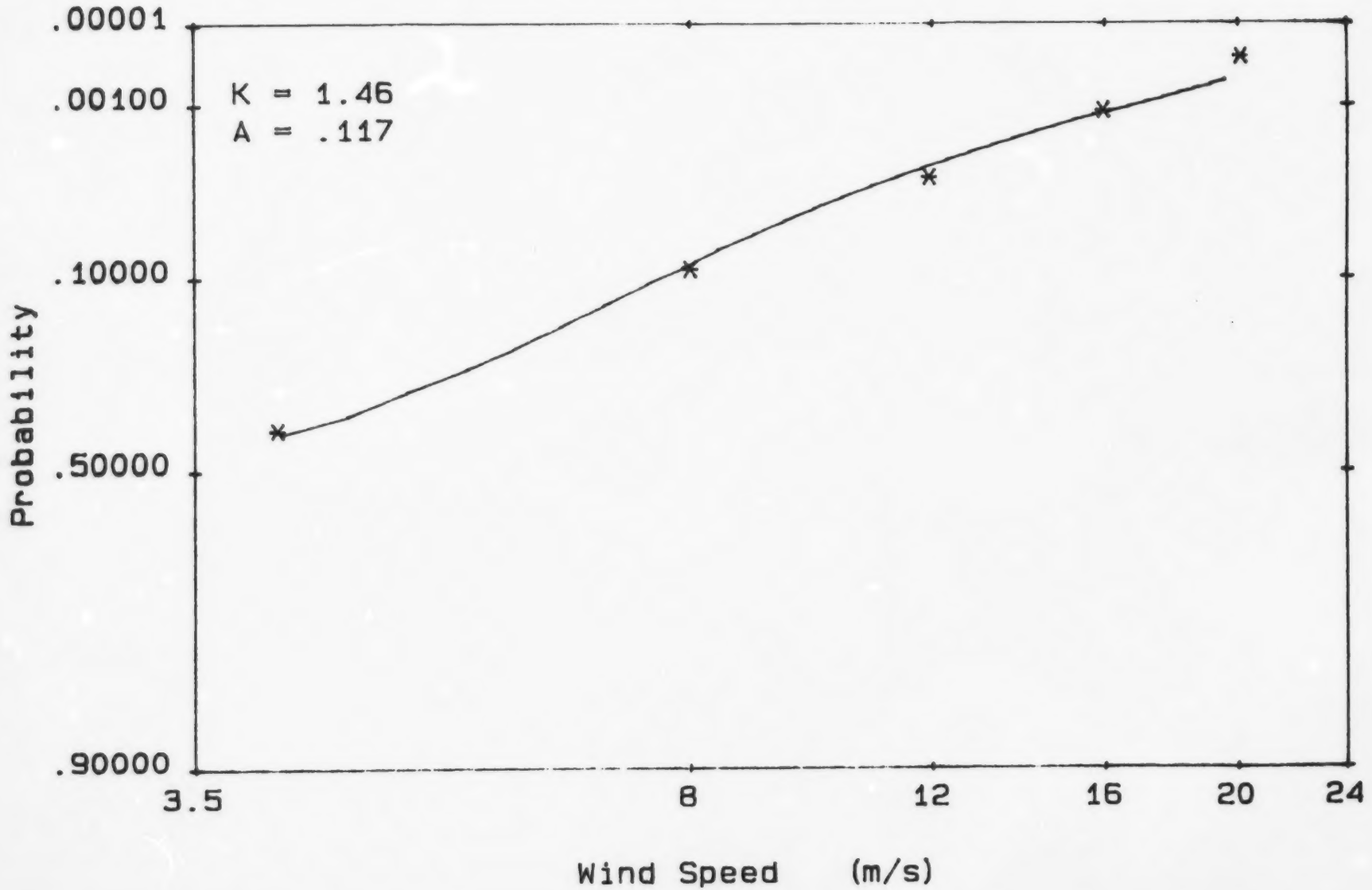
SITE NAME: RATTLESNAKE HILL

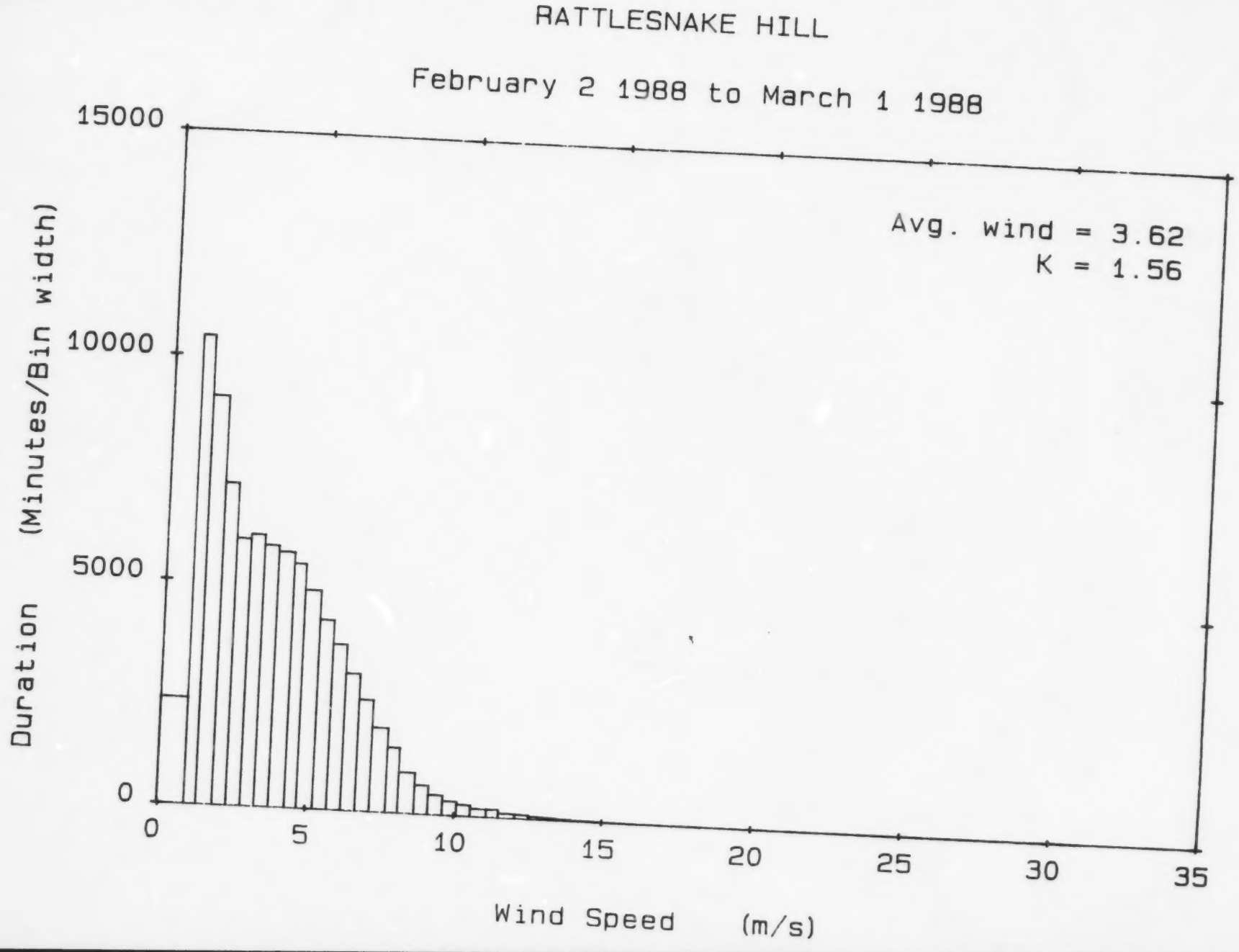
YEAR: 1988

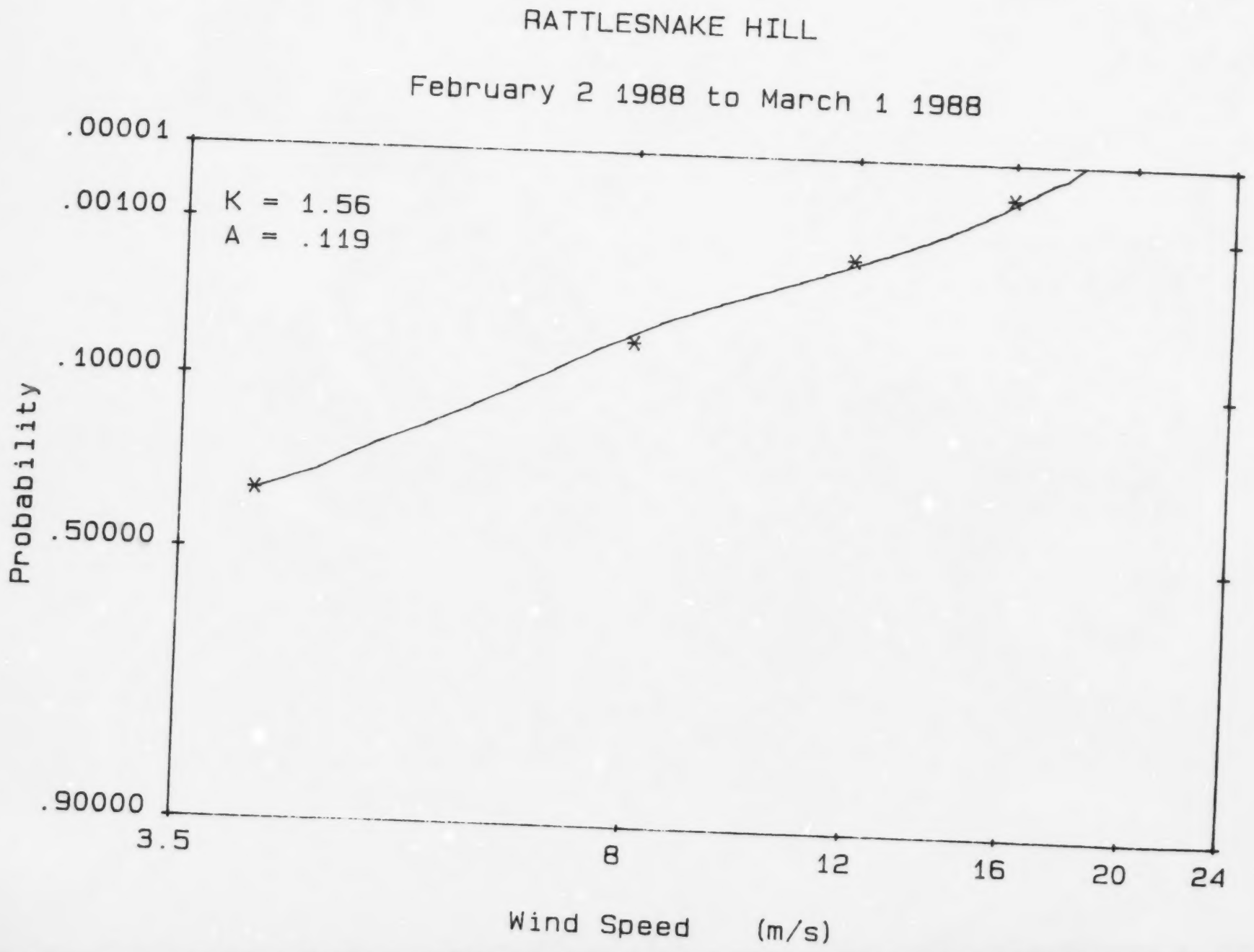
APPROXIMATE MUNTH OF RECORD	TOTAL TIME IN PERIOD HOURS	AVERAGE WIND SPEED M/S	WEIBULL PARAMETER "K"	WEIBULL PARAMETER "A"
January	767.8	4.0	1.46	0.117
February	694.5	3.6	1.56	0.119
March				
April				
May				
June				
July				
August				
September				
October				
November				
December				
YEAR				

Notes:


RATTLESNAKE HILL
January 1 1988 to February 1 1988
Avg. wind = 4.02
K = 1.46
Duration (Minutes/Bin width)
15000
10000
5000
0
0
5
10
15
20
25
30
35
Wind Speed (m/s)


RATTLESNAKE HILL
January 1 1988 to February 1 1988
K = 1.46
A = .117
.00001
.00100
.10000
.50000
.90000
Probability
3.5
8
12
16
20
24
Wind Speed (m/s)


RATTLESNAKE HILL
February 2 1988 to March 1 1988
Avg. wind = 3.62
K = 1.56
Duration (Minutes/Bin width)
15000
10000
5000
0
0
5
10
15
20
25
30
35
Wind Speed (m/s)


RATTLESNAKE HILL
February 2 1988 to March 1 1988
.00001
.00100
.10000
.50000
.90000
K = 1.56
A = .119
Probability
3.5
8
12
16
20
24
Wind Speed (m/s)

Site Log: Rattlesnake Hill

Sep. 1986	The site is now operational. Photographs and topographic maps of the area have been received from the site staff. The site is part of a photo-voltaic pumping demonstration program. The tower is erected on a plateau on the north slope of a hill. The land around the tower is flat and treeless. The land in the distance is mountainous and suggests that the site is centred on a smaller hill in a broad mountain valley.
Mar. 1988	Site removed from study March 1, 1988.

APPENDIX "C"

Rankin Inlet

AIR DENSITY COMPENSATION FACTORS
BASED ON
A.E.S. NORMALS AT THE CLOSEST A.E.S. STATION

SITE: Rankin Inlet

ALTITUDE: 0m

CLOSEST A.E.S. STATION: Whale Cove

STD AIR PRESSURE: 101.33Kpa

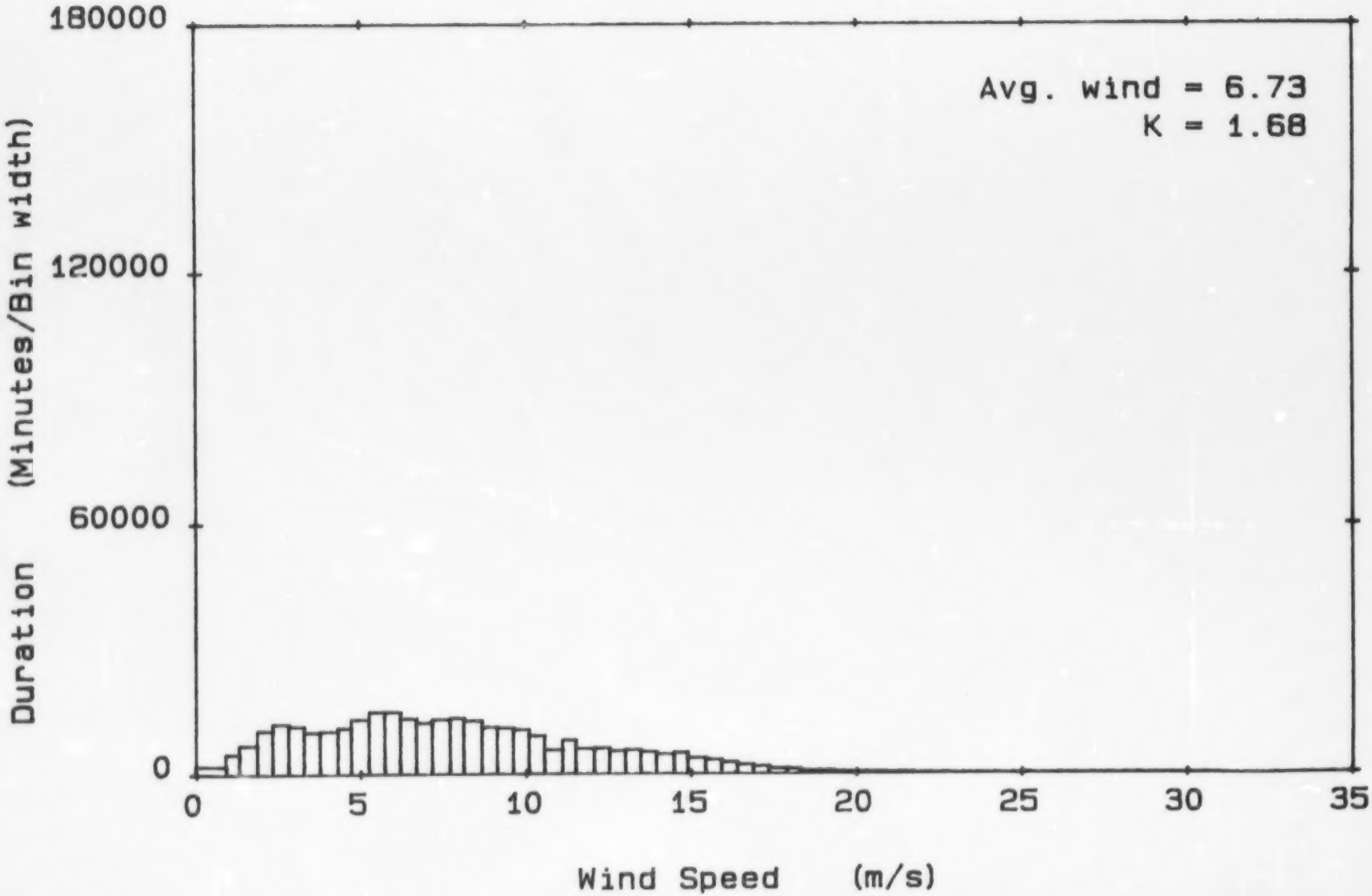
	AVERAGE MONTHLY A.E.S. TEMPERATURE T_{avg} ^{o}K	COMPENSATION FACTOR f_{comp} $f_{comp} = \frac{288.15}{T_{avg}} \times \frac{\text{Std Air Pressure}}{101.33}$
JANUARY	241.6	1.193
FEBRUARY	243.1	1.185
MARCH	247.6	1.164
APRIL	259.0	1.113
MAY	267.6	1.077
JUNE	275.8	1.045
JULY	281.4	1.024
AUGUST	281.9	1.022
SEPTEMBER	279.6	1.031
OCTOBER	269.5	1.069
NOVEMBER	257.0	1.121
DECEMBER	248.1	1.161

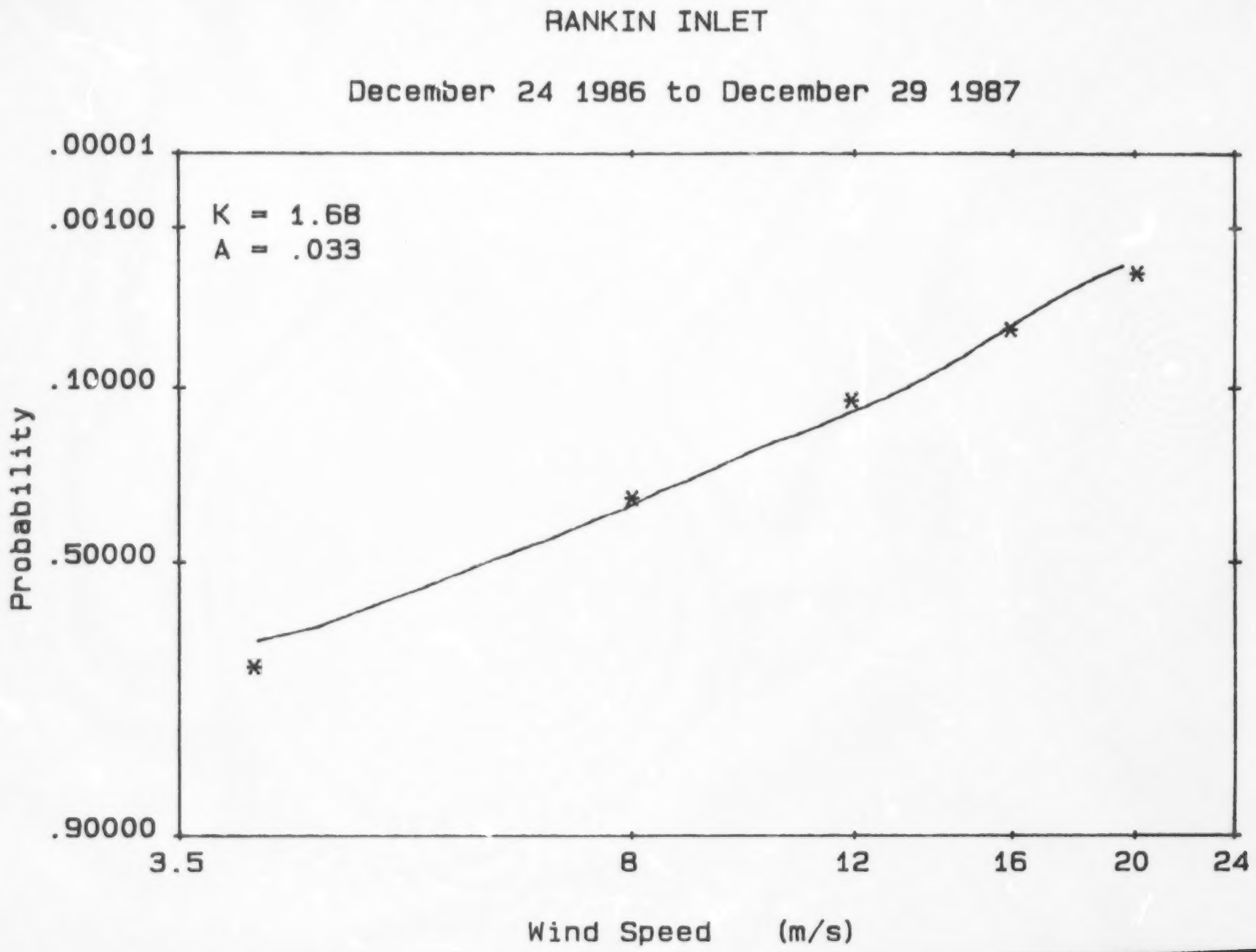
Notes: Compensated Energy Output = Estimated Energy Output x f_{comp}

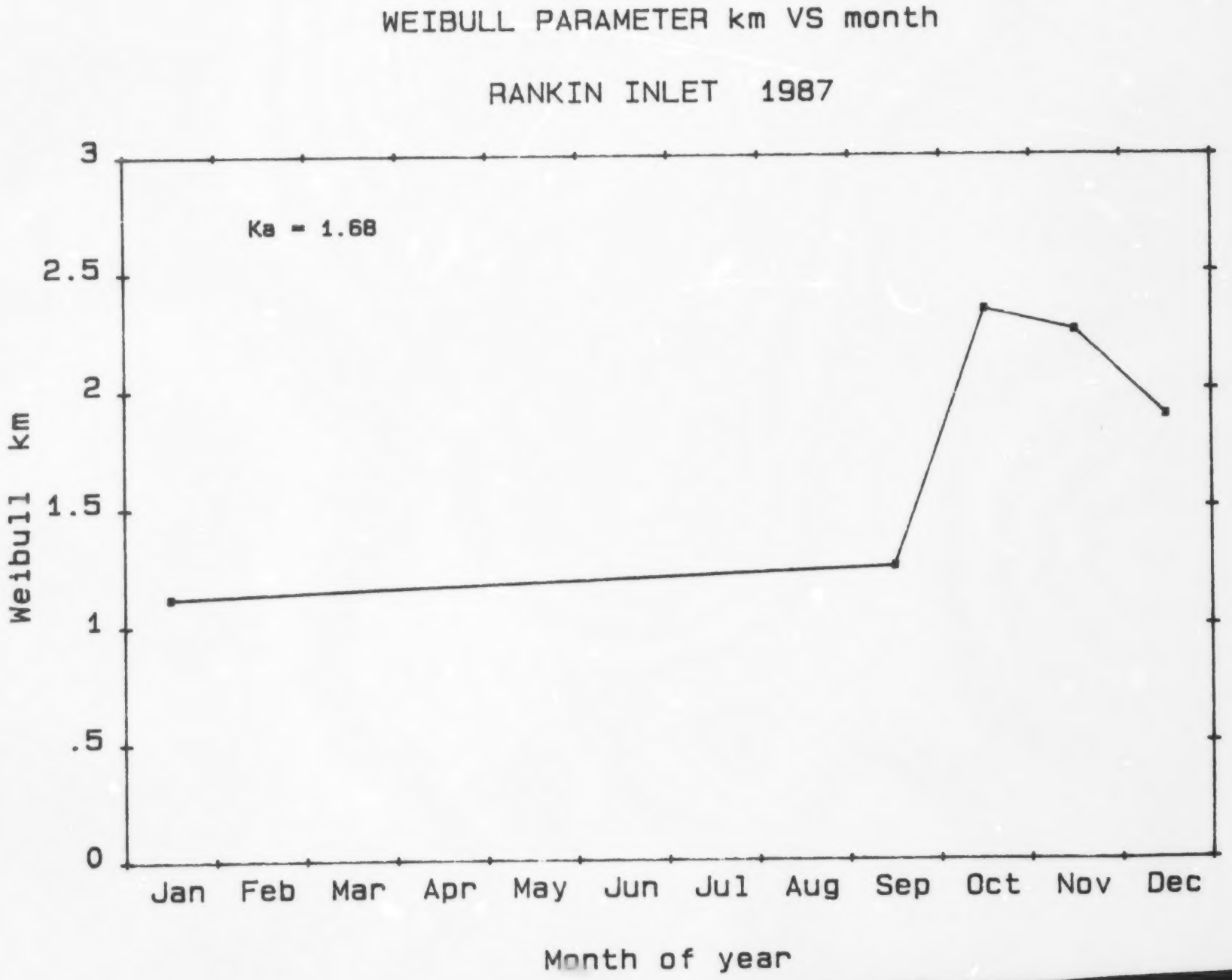
A.E.S. data obtained from Canadian Climate Normals
Temperature 1951 - 1980 UDC: 551.582(71)

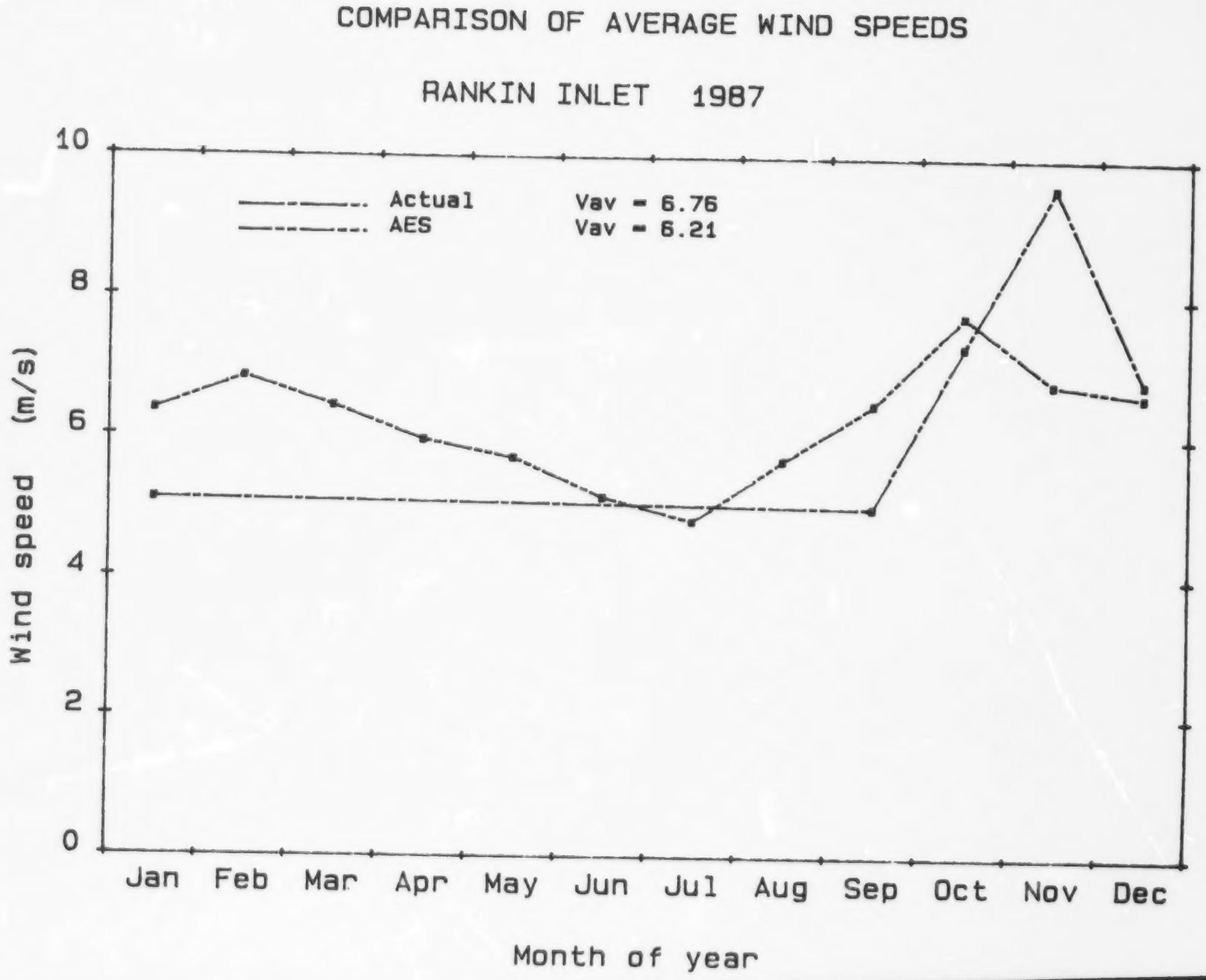
RANKIN INLET

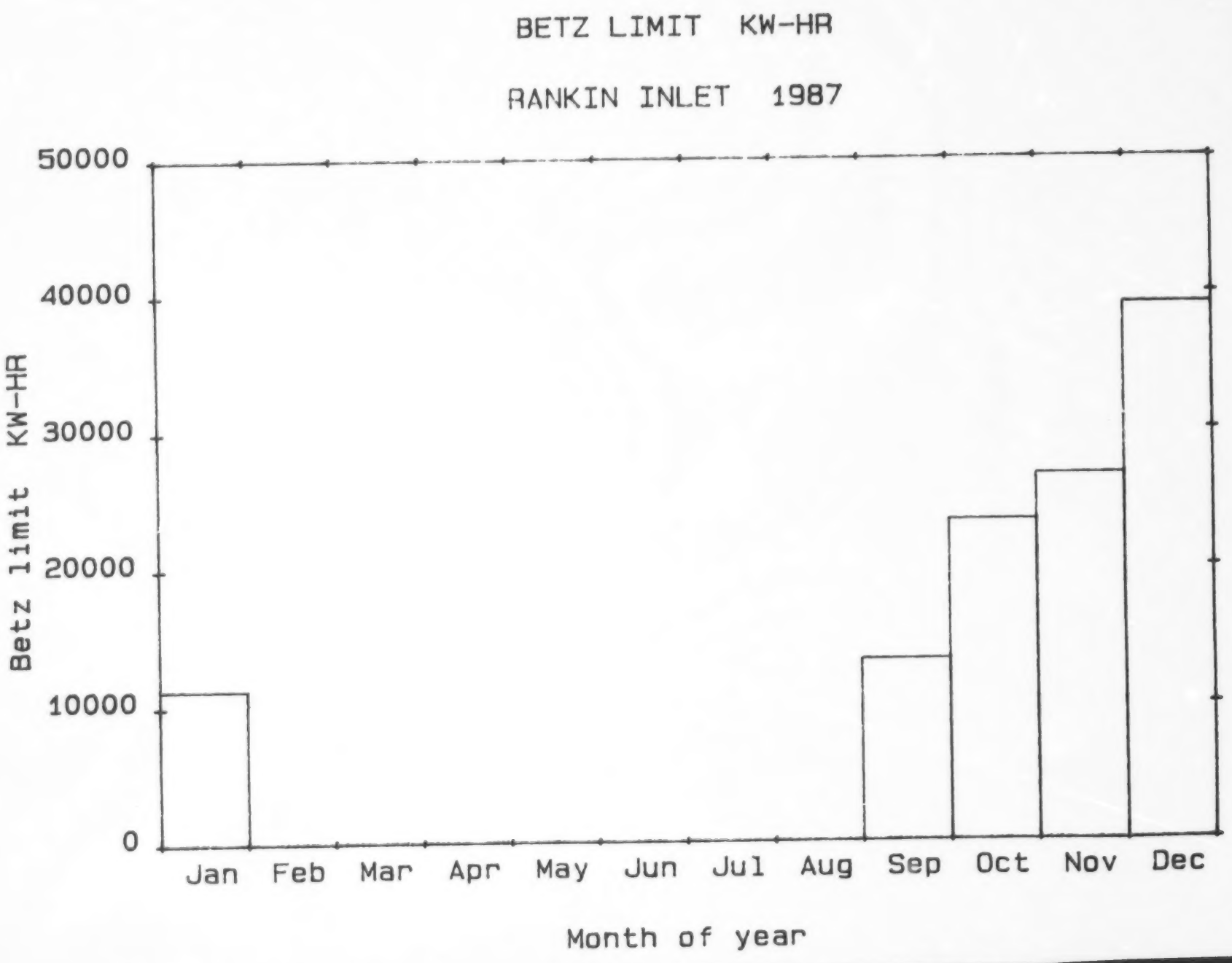
December 24 1986 to December 29 1987




RANKIN INLET
December 24 1986 to December 29 1987
.00001
.00100
.10000
.50000
.90000
K = 1.68
A = .033
Probability
3.5
8
12
16
20
24
Wind Speed (m/s)


WEIBULL PARAMETER km VS month
RANKIN INLET 1987
Ka = 1.68
Weibull km
3
2.5
2
1.5
1
.5
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month of year


COMPARISON OF AVERAGE WIND SPEEDS
RANKIN INLET 1987
Actual
AES
Vav = 6.76
Vav = 6.21
Wind speed (m/s)
0
2
4
6
8
10
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month of year


BETZ LIMIT KW-HR
RANKIN INLET 1987
50000
40000
30000
20000
10000
0
Betz limit KW-HR
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month of year

MONTHLY AVERAGE WIND SPEED
AND WEIBULL PARAMETER "K"
AS CALCULATED FROM CONTINUOUSLY
RUNNING WIND HISTOGRAM RECORDER

SITE NAME: RANKIN INLET

YEAR: 1988

APPROXIMATE MUNTH OF RECORD	TOTAL TIME IN PERIOD HOURS	AVERAGE WIND SPEED M/S	WEIBULL PARAMETER "K"	WEIBULL PARAMETER "A"
January *1 February *1 March April May June July August September October November December				
YEAR				

Notes:

*1 Data not available

Site Log: Rankin Inlet

Mar. 1985	The site manager reports that the batteries are bad. New batteries were sent to the site.
Apr. 1985	The site manager informed T E S that the wind histogram recorder had failed. Replacement equipment was sent out to the site.
June 1985	The wind histogram recorder was restarted on May 30, 1985. Other new equipment was sent to the site in June.
Dec. 1985	All equipment appears to be functioning correctly.
Mar. 1986	The site inspector indicates that the anemometer and cups are still frozen, however, he expects them to be active fairly soon.
Apr. 1986	Site reactivated April 17, 1986.
Jan. 1987	Site reported frozen batteries - January 14.
Feb. 1987	Site reported frozen batteries.
Mar. 1987	Site reported frozen WHR batteries. System frozen.
Apr. 1987	Site reported frozen WHR batteries. System frozen.
May 1987	Site reported frozen WHR batteries. System frozen.
June 1987	Site reported frozen WHR batteries. System frozen.
Aug. 1987	Site reported that WHR batteries have been replaced. System operational.
Sept. 1987	The wind histogram recorder was restarted on September 8, 1987. Equipment appears to be functioning correctly.
Jan. 1988	The wind histogram was not functioning properly in the period December 30, 1987 to February 1, 1988. The internal time-keeping module may require servicing. The cups were reported not spinning February 1, 1988.
Feb. 1988	Time keeping difficulties continued in the period February 2 to March 4, 1988. Data sheets were clearly in error.
Mar. 1988	Site removed from study March 1, 1988.